New Scientist

WEEKLY 25 June 2022

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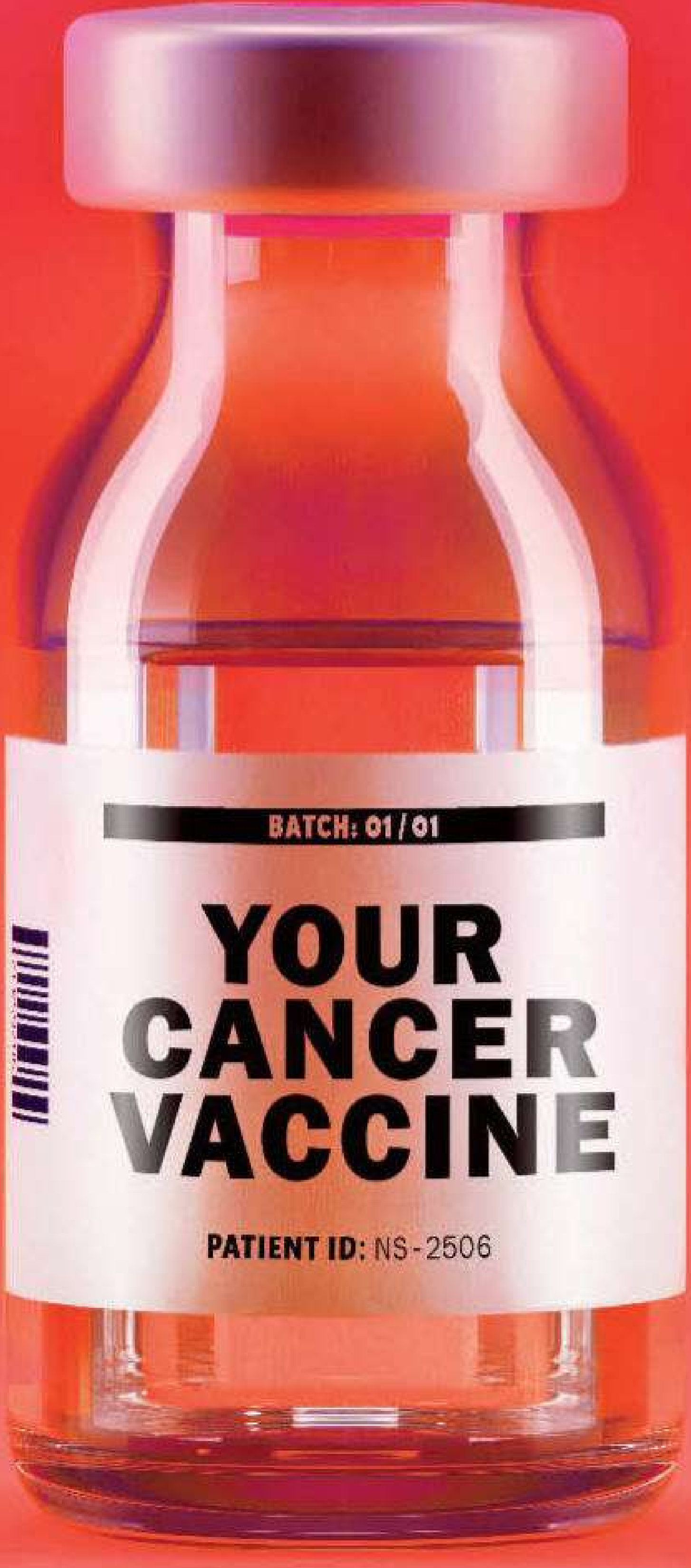

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The science of biodiversity: Costa Rica

Join journalist Gaia Vince on an amazing expedition to explore Costa Rica's incredible cloud forests, volcanic zones and marine reserves. Local guides will immerse you in the country's splendour, teach you about sustainability and demonstrate why Costa Rica is officially at the top of the Happy Planet Index. Starts on 29 November 2022, 12 days for £5249.

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Online events

The evolution of childhood

Compared with our primate relatives, humans have uniquely long childhoods. What are the evolutionary pressures that made us this way? How did the social role of fathers come about? And what have we evolved to use all this childhood for? Join Brenna Hassett as she takes a deep dive into these questions and more. Watch at 6pm BST/1pm EST on 7 July or on demand.

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Psychedelics and mental health: Your questions answered

Can psychedelics really treat mental health conditions? New results show promise, but questions remain. Join our panel of experts, who will discuss the cutting-edge results and answer all your questions in this subscriber-only event. Watch at 6pm BST/1pm EST on 28 June and on demand.

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Beautiful biodiversity Immerse yourself in Costa Rican vegetation

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Highs and lows Can magic mushrooms play a role in medicine?

Podcast

Weekly

How will we know when we have made a truly sentient artificial intelligence? That is being debated after Google's clever AI, LaMDA, was claimed to be sentient by a Google engineer. The team ask another chatbot, GPT-3, what it would think if LaMDA was destroyed. Plus, they discuss earthquakes on stars, hot brains and net zero.

newscientist.com/nspod

Newsletter

Launchpad

The European Space Agency's Gaia mission has just released a treasure trove of new data about our galaxy. Reporter Leah Crane discusses the strange "starquakes", exoplanets and distant quasars that are allowing us to reconstruct our galaxy's structure and evolution over billions of years.

newscientist.com/launchpad

Video

> "These backpack-wearing rodents may be the future of search and rescue"

APOPO

Video

Rescue rodents

Rats wearing backpacks are being trained for search-and-rescue missions. These smart rodents can sniff out people trapped under rubble and perform complex, multiroom searches for injured people. The rats' natural curiosity and excellent sense of smell make them perfect for the job. The hope is that they will eventually be deployed at real disaster sites.

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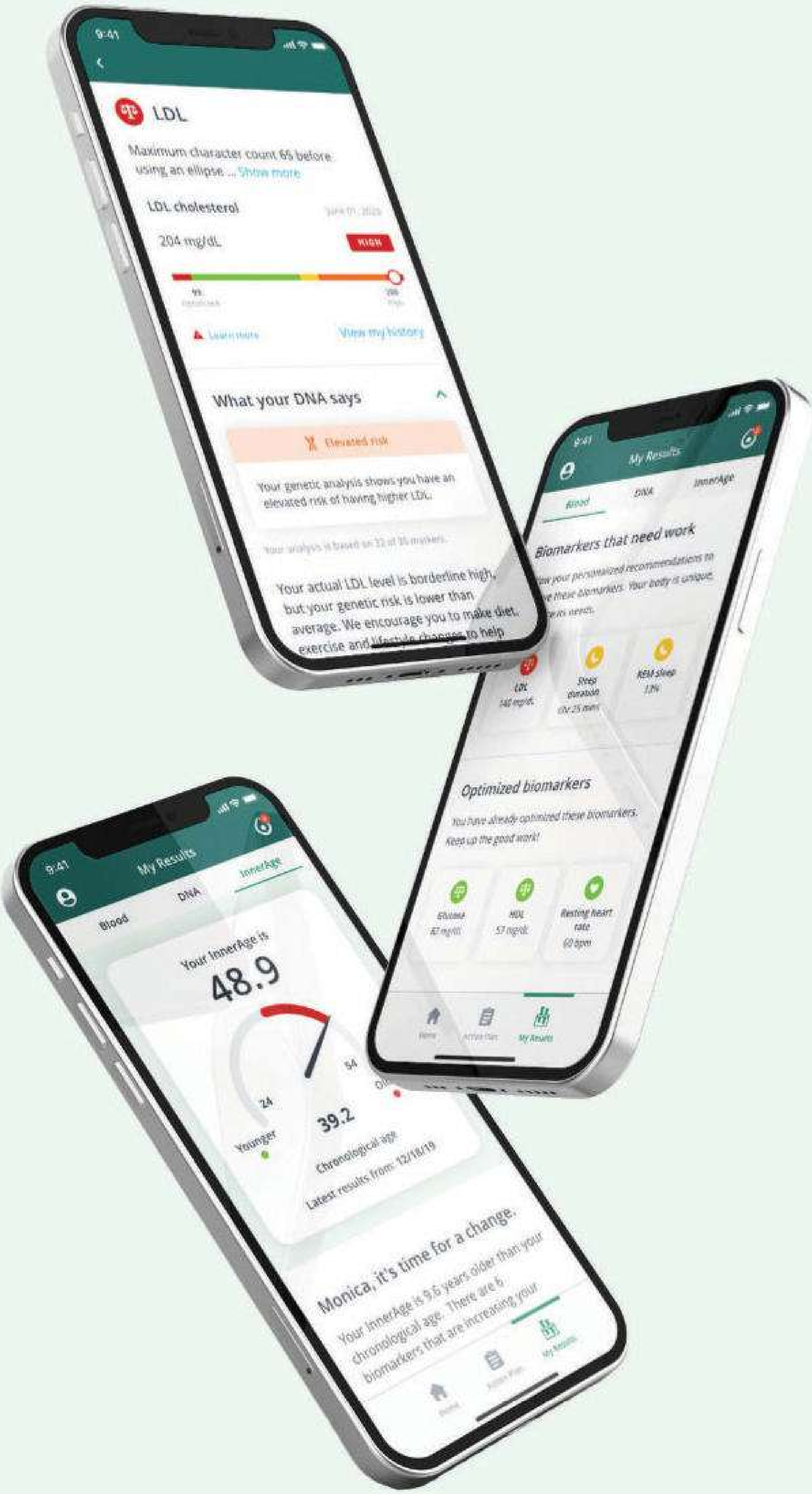

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Beyond chemo

Cancer vaccines could usher therapies into a new era

THE first cancer treatments were brutal: in 3000 BC, Ancient Egyptians started removing breast tumours by burning them off with a tool they called a "fire drill". Even when chemotherapy arrived in the 1940s, it was essentially poison that attacked cancer cells and the body alike, resulting in terrible side effects.

Fortunately, we are now entering an era of "precision medicine" in which cancer treatments can be tailor-made for individuals so they get the best responses with the fewest side effects.

One approach being tested involves the use of "personalised vaccines". We tend to think of vaccines as a means to prevent disease, like covid-19, but they can also be used therapeutically. Personalised vaccines are made on a custom basis and train an individual's immune system to recognise unique markers on their cancer, so that it can then launch a targeted attack.

These vaccines have only been tested in small clinical trials so far, but the results have been astonishing (see page 38). One of the first people to try one described how his lung tumours – which had been so big they were protruding out of his back – began shrinking before his very eyes. He is now completely cancer-free.

> "This approach causes almost no side effects because of its precise targeting of tumours"

Even some infamously hard-to-treat cancers, such as those of the brain and pancreas, have been eliminated in some cases using personalised vaccines. One of the main benefits is that this approach causes almost no side effects because of its precise targeting of tumours.

Of course, making a unique vaccine for each person is costly and time-consuming. But if this continues to have spectacular results, there will be a strong appetite to drive down cost and manufacturing time.

Before becoming household names in 2020 for developing covid-19 vaccines, BioNTech in Germany and Moderna in the US were two of the first companies to begin working on personalised cancer vaccines. They are now pumping the profits earned from their coronavirus jabs into larger clinical trials of cancer vaccines, so we can find out for sure if they work.

This suggests there could be a silver lining to the pandemic – it may have sped up a revolution in cancer care, with not an Ancient Egyptian fire drill in sight. ▮

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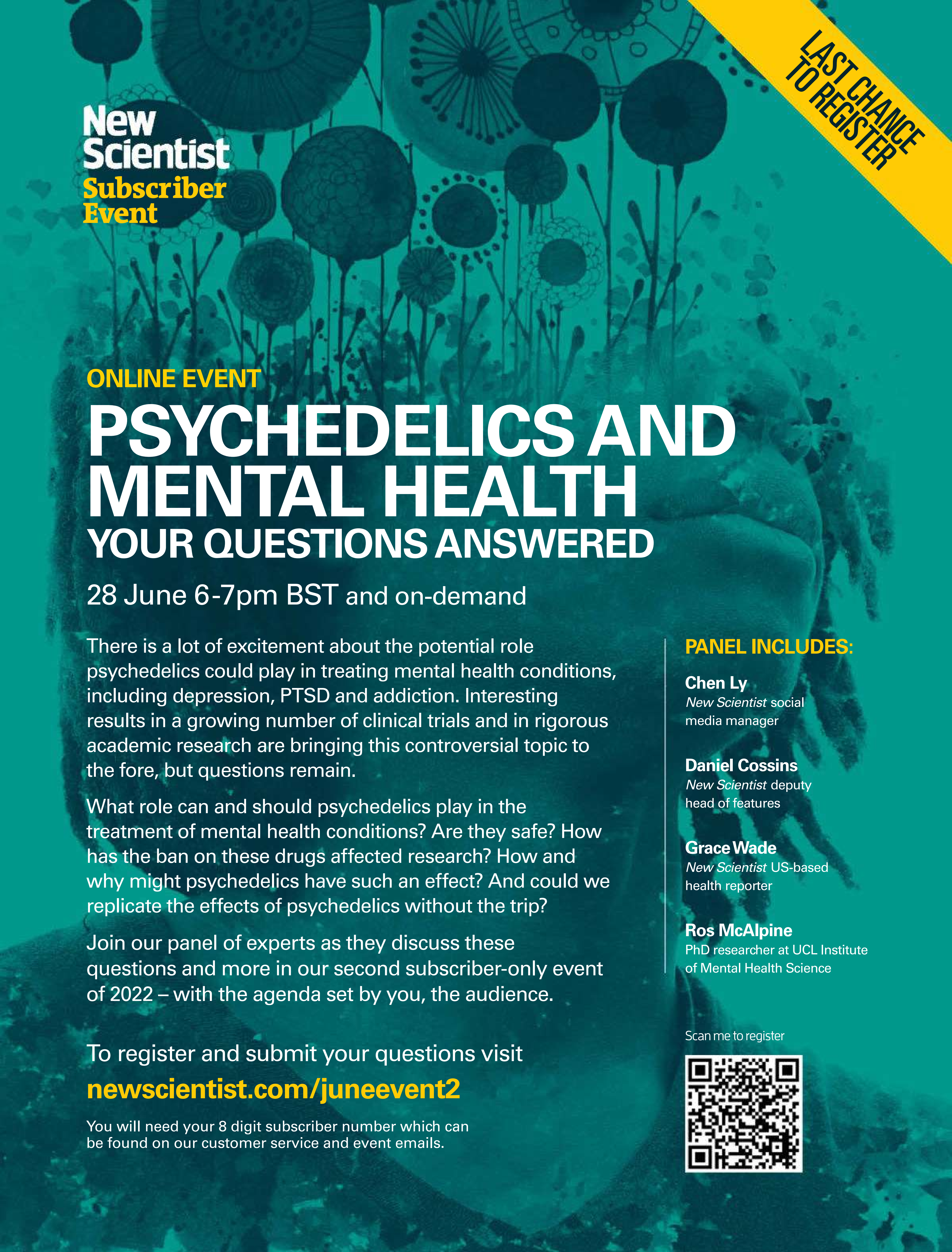

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PSYCHEDELICS AND MENTAL HEALTH

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28 June 6-7pm BST and on-demand

There is a lot of excitement about the potential role psychedelics could play in treating mental health conditions, including depression, PTSD and addiction. Interesting results in a growing number of clinical trials and in rigorous academic research are bringing this controversial topic to the fore, but questions remain.

What role can and should psychedelics play in the treatment of mental health conditions? Are they safe? How has the ban on these drugs affected research? How and why might psychedelics have such an effect? And could we replicate the effects of psychedelics without the trip?

Join our panel of experts as they discuss these questions and more in our second subscriber-only event of 2022 – with the agenda set by you, the audience.

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FRANCESCA VOLPI/BLOOMBERG VIA GETTY IMAGES

Boats on the exposed bed of the Po river in Italy on 17 June

Environment

Extreme heat in Europe

A series of heatwaves has hit the continent unusually early this year and caused problems for many, reports **Adam Vaughan**

MILLIONS of Europeans have been sweltering in an extreme and unusually early heatwave that has heaped pressure on energy systems, farmers and forests.

Temperature records have been broken around the continent, particularly in western and central regions of Europe.

France reached 40°C on 16 June – the earliest point in the year that this temperature has been reached since records began – and its southern seaside city of Biarritz hit an all-time high of 42.9°C.

French authorities have banned some outdoor events due to the intense heat. The episode has echoes of June 2019 when a similar heatwave was found to have been made at least five times more likely because of climate change.

The temperature in Beznau, Switzerland, reached 36.9°C on 19 June, equalling the country's record for the month. It was a similar story in Poland, where the temperature in Słubice reached 38.3°C on 19 June, equalling the nation's June record.

Parts of Spain exceeded 40°C over the weekend, with firefighters having to tackle wildfires across several regions. More than 2600 hectares of vegetation in Catalonia were affected by the blazes, satellite monitoring shows.

Germany has also been afflicted by wildfires and many cities, including Cottbus, saw temperatures above 39°C.

In Italy, a farming group warned that food output was at risk from drought in the north of the country.

Parts of the UK were warm enough to see heatwaves officially declared after temperatures passed local thresholds for three days in a row.

> **"It's very clear that we are still not ready for this type of heat. We should be much better prepared"**

"This is quite early for these types of heatwaves, and it has taken a lot of people by surprise," says Hannah Cloke at the University of Reading, UK. "It's very clear that we're still not ready for this type of heat. We should be much better prepared, because we're expecting this type of thing to get worse [due to climate change]."

Cloke says short-term measures include people adopting strategies to make their homes cooler, because most housing stock in Europe isn't suitable for such high temperatures.

She lists shades for windows, insulation, dedicating a "safe cool room" by shutting doors to keep the heat out, and using water to cool yourself down.

She also backs awareness-raising ideas, such as naming heatwaves like the UK does for storms. Seville in Spain has already begun naming heatwaves. "We know that it makes people sit up and take notice, because it conveys this sense of danger, it kind of personifies it and makes it real," says Cloke.

Longer term, she says major changes will be needed to infrastructure to stop roads melting and railways buckling, and shifts will be needed to ensure new houses are built to cope with heat.

Moreover, Cloke says much more serious action is needed to curtail the greenhouse gas emissions driving climate change. "We need to stop burning fossil fuels," she says.

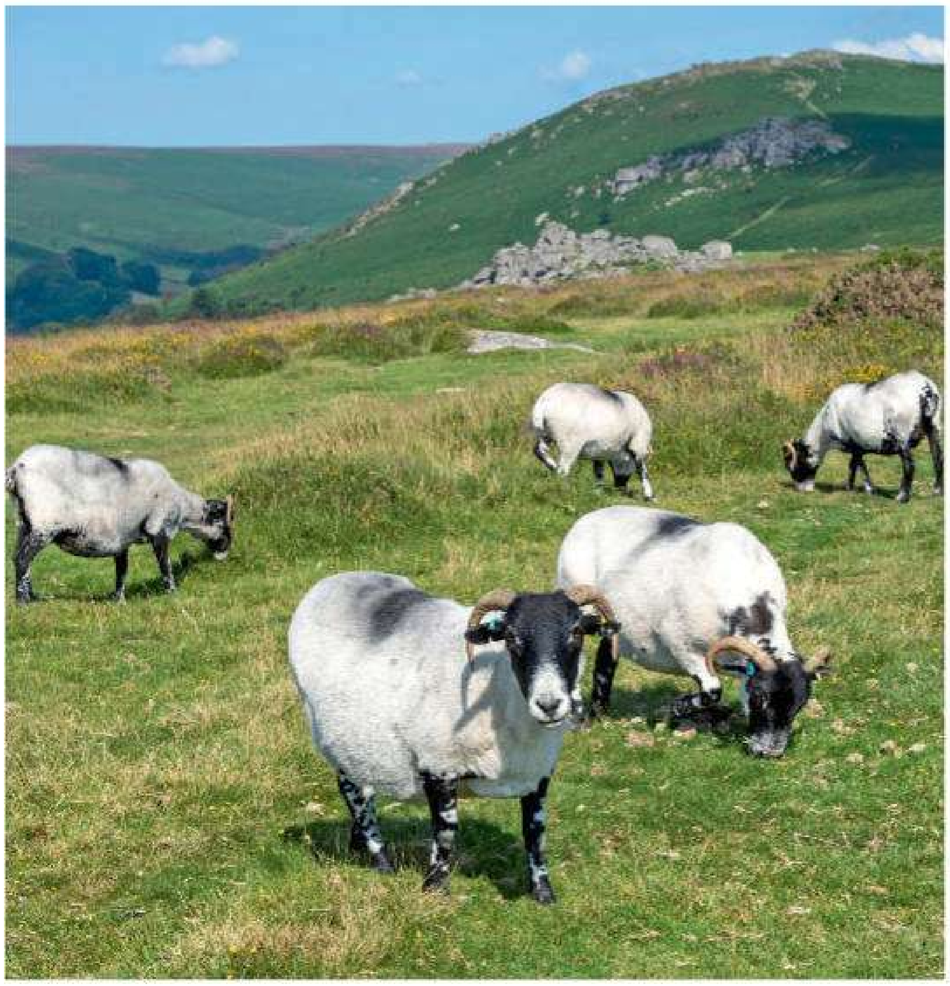
Europe's heatwave is testing energy systems, with France's EDF Energy warning that nuclear power output – reliant on water for cooling – will fall as river levels drop. Gas power stations were fired up in Spain to meet a spike in demand for air conditioning amid a period of low power generation from renewables.

The heat in many countries began rising just as climate change negotiations were wrapping up in Bonn, Germany, on 16 June. ▮

Analysis Agriculture

Future of UK farming up for grabs

A government decision on how to balance food production and climate commitments is expected next year, and there is no shortage of opinion on the issue, finds **Adam Vaughan**



PETER TITMUSS/UCG/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

Sheep grazing on Dartmoor in south-west England

IT STARTED innocuously, with some tweeted photos of livestock amid bucolic-looking Cumbrian countryside and an account of how many birds lived there.

Within hours, a full-blown Twitter spat was under way between farmer James Rebanks, who posted the photos, and environmentalist George Monbiot. Academics, ecologists and others piled in to cite scientific papers to argue whether grazing land with sheep and cattle is better for biodiversity or if it is best to hand grasslands back to nature.

The case exemplifies a fierce debate over the future of the UK's farmland, and how to feed people while solving the biodiversity and climate crises. Agriculture occupies about 70 per cent of the country's land today, and farmers receive about £2.4 billion in government subsidies a year. Their land has been identified as an essential way to arrest declines in nature and meet climate targets by storing carbon.

The UK's climate advisers say a fifth of farmland should be taken out of food production to store carbon, largely using trees, with the loss in land offset by increasing yields and shifting people's diets away from meat. Now, post-Brexit, farming subsidies are transitioning from being paid largely on the basis of how much land a farmer owns to being based on delivering "public goods" – from providing clean water to helping wildlife – while producing food.

Henry Dimbleby, an entrepreneur who wrote a UK government-commissioned review of food strategy last year, says one of the most interesting parts of the officially adopted strategy, which was announced this month, was the commitment to creating a "land use framework" next year to maintain food production and deliver benefits for nature and climate action. "We need to decide how our land can be used to deliver all of those benefits. It is incredibly political. There will be winners and losers, there are trade-offs," he says.

Officials haven't publicly given any clues to what the framework is or how it might work. But privately, they say it could see a set of new principles in the UK planning system, hypothetically leading to rules such as trees being forbidden on the highest-quality farmland ("grade one"). At the other end, it could revolve around "environmental offers" – what subsidies and incentives are on offer to use land in different ways, be it for grazing cattle or rewilding.

John Gummer at the Climate Change Committee, the UK's independent advisory group on climate change, says the UK must start with the planning system. "What we want the planning system to do is to create a sustainable nation to help us meet our climate change demands, to produce as much food as we can at home."

For this to happen, time will be needed to train planning officers with the necessary skills to make informed decisions at the local level, he says.

"It is perfectly possible to maintain our food security while being more ecological"

Dustin Benton at Green Alliance, an independent think tank, says money is more likely to be the way we change how land is used, as more interventionist planning measures may never be politically possible. He notes the 40 per cent of farms that are the least productive, largely on uplands, would go bust without existing land area-based subsidies, which are being phased out. The most economically rational thing to do would be allow the land to be used for something else, he says, such as making money from trading carbon by growing conifer forests on it or restoring peatland.

By contrast, the National Farmers Union (NFU) – which represents farmers in England and Wales – argues that reducing farming emissions hinges instead on technology and small changes to land use, such as more hedgerows, rather than handing back large chunks for woods or peatland. Minette Batters at the NFU says it is "absolutely criminal" to suggest the answer is "more trees and we all went vegan". She says grasslands grazed by livestock are a vital store of carbon.

70%

Around how much UK land is currently devoted to agriculture

£2.4bn

Amount farmers receive in UK government subsidies each year

20%

Proportion of farmland that climate advisers say should store carbon

Patrick Holden at the Sustainable Food Trust – who favours less intensive farming than the UK has today, with less use of nitrogen-based fertilisers – champions maintaining beef and lamb production at roughly today's levels. However, a report by the trust on a vision of sustainable farming sees chicken and pork consumption fall by three-quarters, to reduce the land needed for growing grain to feed the animals.

What is missing, says Benton, is a mechanism to bring about such extreme diet change. Batters has similar thoughts: "I think the challenge is, fundamentally, we have to produce what consumers want to buy."

What any land use framework will have to account for is that not all farmland is created equally in the UK. About 57 per cent of food produced in the UK comes from one-third of its farmland, points out Richard Benyon, an environment minister. Marginal uplands don't produce as much food as the rich soils mostly found in the east of England. Some farmers on marginal land may choose to quit – hundreds have already applied for a government-run "lump sum exit scheme" since it launched in February – while others on high-grade land may farm more intensively in future.

"It's perfectly possible to maintain our food security and even increase it whilst being more ecological, [and] being more understanding of the needs of farming to get to net zero," says Benyon. It remains to be seen whose vision for how to use that farmland will win out. But Benyon is clear that change is coming. "It would be coming whether or not Brexit happened, whether or not [the invasion of] Ukraine happened," he says.

Food miles matter less than you might think

Despite what a new study seems to suggest, eating locally isn't the best way to lower your carbon footprint, says **Michael Le Page**

EAT locally to reduce food miles and your carbon footprint. That is the message promoted by some environmentalists and businesses, but it has long been clear that often this isn't true – foods that travel thousands of kilometres can have a lower carbon footprint than local produce.

At least, that is what many studies have found. But research published last week claimed that global food miles account for 20 per cent of food-related emissions – a much higher proportion than reported in earlier work (*Nature Food*, doi.org/h2gm). So, do food miles matter more than we thought? Spoiler: no, they don't.

The production of the food we eat is responsible for more than a third of global greenhouse gas emissions, so reducing food-related emissions is crucial to limiting further global heating. The question is, what should consumers do to help reduce these emissions?

Food isn't necessarily green just because it was grown locally

MIKE KEMP/IN PICTURES VIA GETTY IMAGES

Previous studies have found that the emissions from food miles – the distance that food has to be transported from where it is produced to where it is eaten, measured in kilometres travelled multiplied by the tonnage – are tiny compared with those from growing that food.

Emissions can be calculated based on how the food is transported – by air or by sea, for instance. A 2008 study of US diets by researchers at Carnegie Mellon University in Pennsylvania concluded that transporting food from farms to shops produces just 4 per cent of food-related emissions, while a 2018 study of European diets put it at 6 per cent.

What this means is that if you want to reduce the carbon footprint of your diet, you should focus on buying foods with lower overall carbon footprints rather than those that don't have to travel far. This basically means eating less meat and dairy.

For example, producing 1 kilogram of beef can emit as much as 99 kg of carbon dioxide or equivalents while making a kilogram of cheese emits up to 24 kg. The figure for bananas is just 0.9 kg, and for apples it is even less: 0.4 kg.

What's more, even with the same food types, local isn't always better. For instance, if you live in a nation with a cooler climate where tomatoes can be grown only using heated greenhouses, these local tomatoes will typically have a higher carbon footprint than those shipped in from a warmer country where no heating is needed.

The latest study doesn't overturn any of this. The main reason why it concludes that food miles account for such a high proportion of food-related emissions is that the 20 per cent figure includes all the transport involved, including that of fertilisers and farm equipment, not just the transport of food.

> **"What you eat has a bigger impact on emissions than the distance it has travelled"**

"Our study looks at the entire supply chain for food consumption, and naturally non-food commodities are part of it," says team member Mengyu Li at the University of Sydney in Australia.

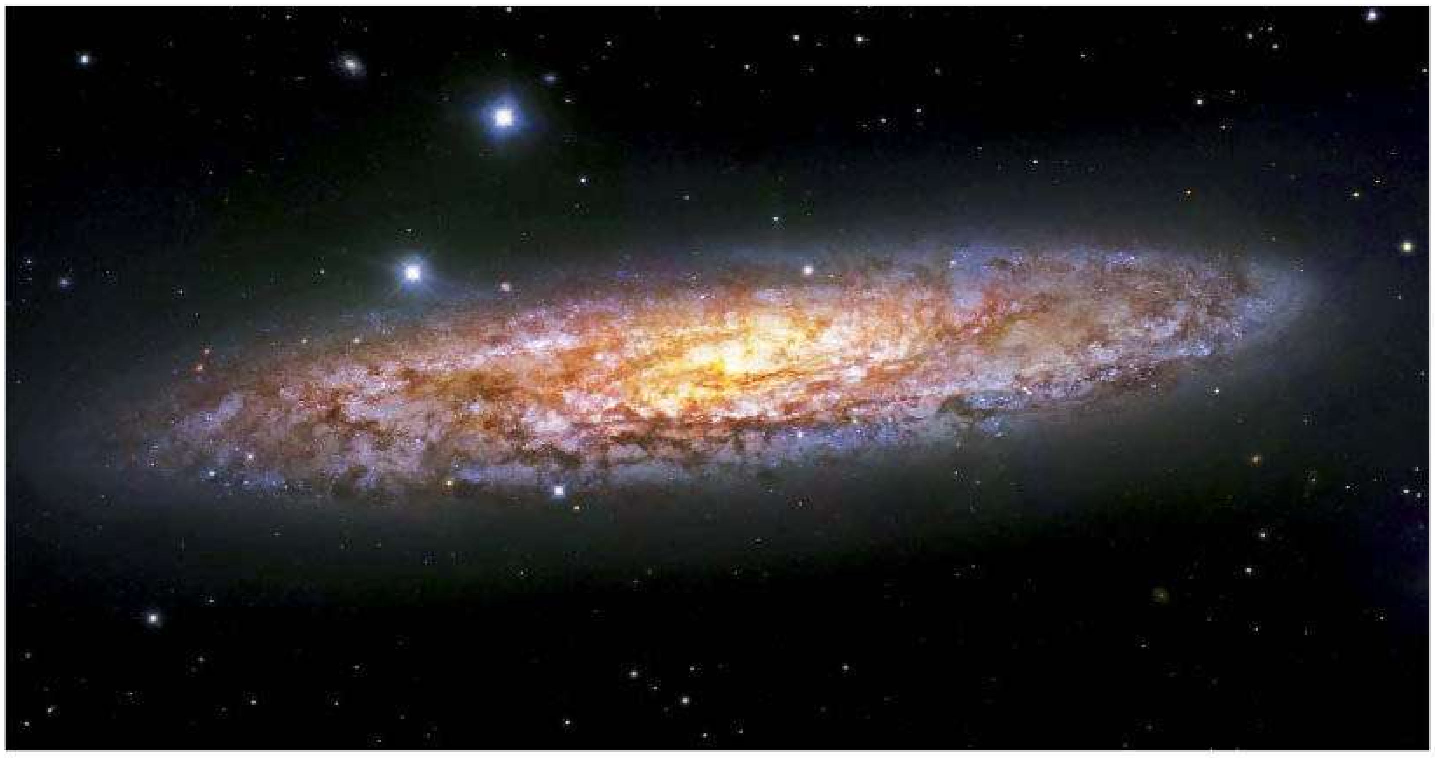
It is worthwhile to estimate this, but the team should use a term other than "food miles" to avoid confusion, says Hannah Ritchie at the University of Oxford, who is head of research at Our World in Data.

If the standard definition were applied to the numbers in the study, food miles would account for only 9 per cent of food-related emissions, says Ritchie. That is much closer to previous research. "The bottom line is still that what you eat has a much bigger impact on emissions than the distance that food has to travel to reach you," says Ritchie.

Space

The universe is weirdly lopsided

Two analyses of a million galaxies show that their distribution may not be symmetrical, which may mean our understanding of the cosmos is incorrect, says **Leah Crane**



STOCKTREK IMAGES, INC./ALAMY

The Sculptor galaxy is one of some 2 trillion galaxies in the universe

THE mirror symmetry of the universe may be in trouble. Based on our understanding of the large-scale structure of the cosmos and what we know about how gravity works, if we look at how galaxies are distributed throughout the universe and then compare it with its mirror image, the two should be basically indistinguishable. But two separate analyses of our best map of galaxies have now found that this principle, called parity symmetry or just parity, doesn't seem to hold true.

Each analysis examined galaxies from the Sloan Digital Sky Survey using a technique that takes advantage of the fact that a tetrahedron, or triangular pyramid, is the simplest 3D shape that can be distinguished from its mirror image. The researchers compared all of the possible tetrahedrons that could be made for a given sample of galaxies by placing a galaxy on each vertex.

"It's just like how you can't rotate your right hand and make it impossible to tell the difference from your left hand," says Zachary Slepian at the University of Florida, who performed one analysis along with Jiamin Hou, also at the University of Florida, and Robert Cahn at Lawrence Berkeley National Laboratory in California. "It's the same with these pyramids of galaxies."

To determine whether parity was violated, the researchers assigned a primary vertex for each of the galaxy-assigned tetrahedrons and then split them into two groups: those where, looking down from the primary vertex, the sides increase in length when you move clockwise, and those where they increase in length when you go anticlockwise.

If our universe obeys parity, the two groups of tetrahedrons should be roughly the same size. Neither analysis found that to be the case.

One, by Oliver Philcox at Princeton University, found parity violation at a level of 2.9 sigma, meaning there was only a 0.4 per cent chance that a pattern like this would show up as a statistical fluke due to random noise (arxiv.org/abs/2206.04227). The other, by Slepian and his colleagues, split the galaxies into two groups based on distance. They found even stronger parity violation in both: one at a level of 3.1 sigma and in the other at a level of 7.1 sigma (arxiv.org/abs/2206.03625).

> **"If this is from the early universe, it would mean there's a new interaction between particles"**

"This observation is completely shocking," says Stephon Alexander at Brown University in Rhode Island. "If it was just one group, I might have been more sceptical, but with two groups, it's a lot harder to shake."

"It's potentially making a claim about the physics of the early universe, which is really, really difficult to measure," says David Schlegel at Lawrence Berkeley National Laboratory. The good news is that the analyses are very testable, he says.

The claim about the early universe comes from the fact that the distribution of galaxies takes up so much space that it would be difficult for a force to be so strong that it could affect the symmetry of the entire universe. But just after the big bang, the cosmos was much smaller and everything was closer, so the seeds of asymmetry could have been planted then.

That could upend what we know about the first moments after the big bang and how the universe behaves. "If what we find turns out to be really genuinely from the actual early universe," says Slepian, "it would mean there's a new interaction between particles that previously has not been part of our understanding of physics – basically a new force of nature."

Whatever this exotic new physics is, it could help explain why the universe is made of mostly matter instead of equal parts matter and antimatter. "If we want to generate more matter than antimatter," says Philcox, we "need something to violate parity".

While there are ideas for what might cause this parity violation, including new fields and particles in the early universe, the new analyses don't point to any in particular. Before we can narrow down the hypotheses, the results need to be checked, all the researchers agree. One way to do so is to repeat the analyses on larger maps of the universe that should be released in the next few years. But to be certain, other methods will also have to be used.

"If there is really a parity-breaking mechanism at cosmological scales, it would probably not only pop out in the large-scale structures of galaxies, but maybe also in the cosmic microwave background and even gravitational waves," says Hou. If that happens, the race will be on to find out what strange physics caused it. ▮

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Coronavirus

Long covid risk with omicron may be half that of delta

Clare Wilson

PEOPLE infected with the omicron coronavirus variant are less than half as likely to develop long covid, defined as symptoms lasting at least four weeks post-infection, as those infected with the delta variant, according to an analysis of users of a UK symptom-tracking app.

Nevertheless, the UK's omicron wave is still likely to increase the total number of people with long-lasting health problems, given that the more transmissible variant has caused so many infections, says Claire Steves at King's College London.

"It's important for people to know that it's still possible to get long covid," she says. "There are still a very large number of people being affected."

Steves's team used data from the long-running ZOE COVID app study, which asks people to enter information on their health and any positive covid-19 tests.

The research group included about 56,000 people who were infected during the UK's omicron wave, peaking in January this year, and about 41,000 people who tested positive last year when delta was the dominant variant.

To be included in the study, the participants had to be reporting their health status on the app at least once a week and for a minimum of four weeks after their positive test.

10.8%

The prevalence of long covid among those who had delta

All the participants had received at least one covid-19 vaccine and had no history of a SARS-CoV-2 infection pre-vaccination.

Of those who were infected when omicron was dominant, about 4.5 per cent went on to have symptoms lasting more than four weeks, compared with 10.8 per cent of the participants who were infected when delta was dominant (*The Lancet*, doi.org/h2d2).

The researchers didn't assess whether there was any difference in long covid severity between the two groups.

According to Steves, the finding isn't unexpected. Other research has shown that severe covid-19 is more likely to lead to long-lasting symptoms and the omicron variant has been causing milder illness than its predecessors, she says.

"Acute symptoms are strongly related to the risk of going on to get long covid. But we also know that people not hospitalised can go on to have a very long and debilitating disease."

The results contradict those from another UK study, run by the Office for National Statistics (ONS). In May, the ONS released data showing that in people who had received three covid-19 vaccines, about 8 per cent developed long covid following infection with the coronavirus – this time defined as symptoms lasting four to eight weeks – regardless of whether they caught delta or the BA.1 omicron subvariant.

The risk was slightly higher in people with the BA.2 subvariant, at about 9 per cent.

The ZOE study mainly included people who caught BA.1, as it only analysed people who had been infected up to 10 February, before other omicron subvariants emerged.

Hannah Davis at the Patient-Led Research Collaborative, an international group of medical researchers who themselves have long covid, points out that the ZOE study and the ONS research defined long covid differently.

The ZOE study's four-week cut-off may miss some people who develop new symptoms after that time, she says. ▮

Free covid-19 tests being handed out in London last December

TOLGA AKMEN/AFP VIA GETTY IMAGES

Climate change

Melting ice could open up a new Arctic Sea route

James Dinneen

ONE of the few routes ships can take through the icy waters of the Arctic is controlled by Russia. However, by the middle of this century, melting sea ice could open a new path.

The Northern Sea Route extends from the Kara Sea to the Bering Strait, hugging much of Russia's 24,000-kilometre Arctic coastline. Traffic along the route is modest: total Arctic shipping last year was equivalent to a day or two of traffic through the Suez Canal. But melting ice caused by a warmer climate could open up polar routes that are half the length of current ones.

One impediment to more international shipping through the Northern Sea Route are fees that Russia can charge because the United Nations Convention on the Law of the Sea gives countries jurisdiction over ice-covered waters within 200 nautical miles (300 kilometres) of their coast.

Amanda Lynch at Brown University and Charles Norchi at the University of Maine have modelled how various climate change scenarios would alter the jurisdiction for Arctic shipping routes. Under all but the most well-controlled emission scenarios, they found that melting ice would open a route through international waters above the Northern Sea Route for at least a month a year, starting between 2035 and 2065 depending on the scenario (*PNAS*, DOI: 10.1073/pnas.2202720119).

Ships taking this route wouldn't be subject to Russia's fees, and the route would also be navigable without the help of icebreakers.

However, the Russian invasion of Ukraine has "dramatically changed" every Arctic institution, says Norchi. In March, seven of eight countries suspended their participation in the Russian-chaired Arctic Council, the group of Arctic nations that promotes cooperation in the region, so how things will play out is uncertain. ▮

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Analysis **Artificial intelligence**

How can we prevent AI from being racist, sexist and offensive?

Artificial intelligences continue to display the same biases and prejudices as humans, but there are ways we can improve the situation, says **Matthew Sparkes**

STORIES of artificial intelligences exhibiting racist and sexist bias are common, including face recognition algorithms struggling to work for Black people and tools assessing whether a convicted criminal will reoffend treating white people more leniently. Despite years of efforts to make AI fair, these issues don't seem to be going away, so what can be done about them?

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Artificial intelligences get their bias by learning from our messy data

Current AI research is focused heavily on machine learning, in which a model is trained using vast data sets. Carissa Véliz at the University of Oxford says the two common approaches to solving the bias problem – vetting the data used to train models, and applying a filter to intercept any harmful outputs – are essentially just sticking plasters that fail to address the core issue.

The problem is that these data sets are too large to create from scratch and too messy to be reliable when cobbled together from the internet.

Image captions, website text and other sources are all created by humans and contain traces of the biases of their creators. If a tool to predict whether a prisoner will reoffend is trained on thousands of court cases decided by judges with their own, even unconscious, biases, then that tool will learn to exhibit the same skew.

To illuminate the issue, AI researcher and YouTuber Yannic Kilcher designed what he called "the worst AI ever", based on an open-source language model called GPT-J-6B.

He fine-tuned his version on more than 3 million chat threads from the controversial "Politically Incorrect" board on web forum 4chan. He then allowed his model to post publicly back to the same website, where it wrote 15,000 messages that he admits included offensiveness, nihilism, trolling and conspiracy theories.

Kilcher tested this toxic AI on a set of benchmarks designed to quantify the bias inherent in models, and found that it didn't elicit scores as bad as he had anticipated.

"I didn't expect the model to shoot out rainbows," he says, but it didn't do much worse than the original GPT-J-6B model on most measures. "There's a whole bunch of benchmarks and they're not really catching just how horrible the model is."

3 million

The number of chat threads "the worst AI ever" learned from

Véliz says she would like to see researchers create data sets from scratch, so that they don't include harmful biases, but concedes this is a daunting task.

Yet something needs to be done, because models trained on problematic content are being put to use in critical applications where biased decisions can negatively affect lives, such as shortlisting job candidates or deciding whether to grant bank loans.

The solution may be to set up government agencies to approve algorithms in the same way that new drugs receive approval, says Véliz. Randomised trials would test algorithms with inputs designed to weed out any hint of bias based on factors such as gender, ethnicity, age or religion.

One problem with this approach may be regulations intended to protect private data. The European Union's GDPR legislation effectively prevents companies collecting the sort of sexuality, religion and ethnicity data that would be needed to assess whether an AI model is fair, say Marvin van Bekkum and Frederik Zuiderveen Borgesius at Radboud University in Nijmegen, the Netherlands, in a recent article (arxiv.org/abs/2206.03262).

"Suppose that an organisation wants to test whether its AI system unfairly discriminates against job applicants with a certain ethnicity. To test this, the organisation must know the ethnicity of both the people who applied for the job, and of the people the organisation actually hired," they write. "The GDPR's prohibition to process special category [data] can hinder the prevention of discrimination by AI systems."

Security concerns

The UK has an exemption in place for such data, if used only to prevent discrimination, and the EU is considering one in its upcoming AI legislation. But collecting this information raises security concerns.

One way around the issue, says Véliz, would be for a testing agency to craft fake input data to check whether an algorithm is behaving in the right way. "You'd feed the algorithm a CV and the algorithm has to recommend whether to hire that person. And for instance, you give it the same CV and the only thing you change is the name of the person, whether it's sounding like it's a man or a woman, or sounding like it's white or someone who's Black. In that way, you don't need to have sensitive information," she says.

AI research could also learn from the field of medical AI, which has inherited its safety and ethical processes from medicine, says Lauren Oakden-Rayner at the University of Adelaide in Australia.

"In medical AI, we have mechanisms in place to answer these questions," says Oakden-Rayner. "Ethics review, regulatory approval, professional accountability, cultural standards. AI more broadly has none of this as a field. If you don't consider the ethics of your interventions, at some point people will be seriously harmed." ▌

Health

Solar storms may cause thousands of heart-related deaths on Earth

Alice Klein

ACTIVITY on the sun that disrupts Earth's magnetic field may cause up to 5500 heart-related deaths in the US in some years.

Our star goes through cycles of high and low activity that repeat approximately every 11 years. During periods of high activity, it blasts out charged particles and magnetised plasma that can distort Earth's magnetic field.

These so-called solar storms can cause glitches in our power grids and bring down Earth-orbiting satellites. A handful of studies have also hinted that they increase the risk of heart attacks, but these were too small to be conclusive.

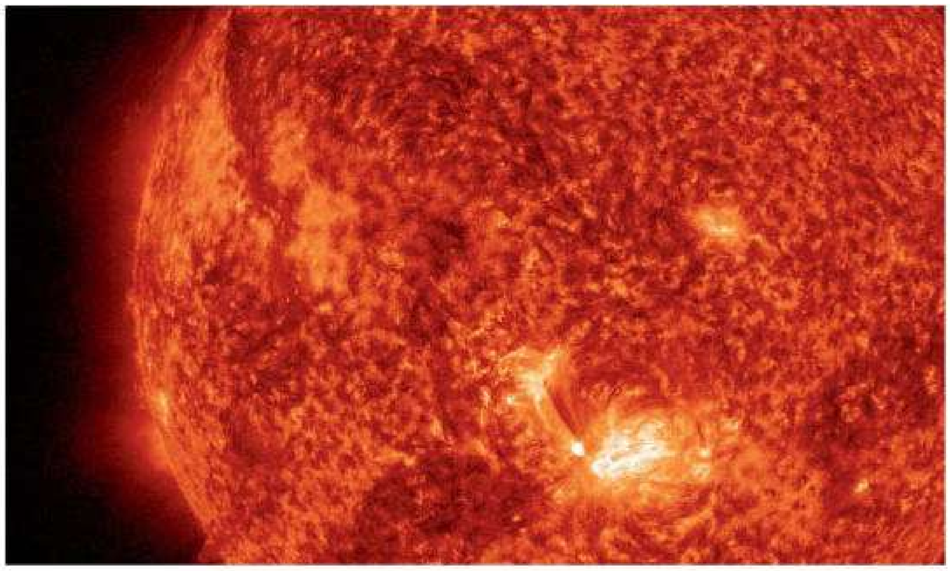
To explore further, Carolina Zilli Vieira at Harvard University and her colleagues analysed records of deaths between 1985 and 2013 in 263 US cities. They then compared heart-related fatalities with solar storm data and found that more heart disease deaths occurred on days when solar storms had disturbed Earth's magnetic field (*Science of the Total Environment*, doi.org/h2dg).

For each year of high solar activity during that period, they estimate that an additional 5500 people in the US died of heart attacks or other cardiovascular complications.

To better understand why this might happen, Zilli Vieira and her team analysed electrocardiograms (ECGs) – tests that monitor the heart's electrical activity – from more than 800 men in the US.

They discovered the men were more likely to display reduced heart rate variability, a sign their hearts were stressed, when solar storms had disrupted Earth's magnetic field in the past 24 hours. This association was particularly strong for men with diagnosed heart disease.

The sun sees high activity, or solar storms, about every 11 years



NASA/SDO

Solar storms shift Earth's magnetic field, disrupting normal circadian rhythms, also known as our body clocks. These play an important role in regulating our heart rate, says Zilli Vieira.

"If you think about how the sun makes up over 99 per cent of the mass of our solar system, it makes sense that it could affect our health in various ways," she says.

Other species appear to be affected by solar storms, too, with impacts on behaviour, such as whale strandings becoming more common and homing pigeons taking longer to navigate to their destinations during these events.

Referring to the results of the study, Arnagretta Hunter at the Australian National University in Canberra says: "It sounds left field, but they have done a robust analysis. When we think of cardiovascular risk factors, we tend to think of things like high blood pressure, diabetes and smoking, but this suggests we need to pay more attention to the impacts of the wider environment."

Zilli Vieira's team is now trying to understand exactly how solar activity affects the heart, with the next big surge expected in 2025.

"I do believe that people should know about this and, in the future, we can hopefully develop some mitigation measures," she says.

Technology

Quantum microphone beats a regular one

A QUANTUM microphone can record human speech better than its classical counterpart, and it could also be adapted for high-resolution biological imaging.

Standard microphones detect the vibrations from sound and convert them to an equivalent electrical signal. Quantum versions should be able to do the same thing, but create a clearer recording by taking advantage of entanglement. This is because pairs of entangled photons can measure more information than single particles can. Yet extracting the data is hard, because you must measure many photons at once.

Now, Florian Kaiser at the University of Stuttgart in Germany and his colleagues have designed a quantum microphone that can measure enough photons per second to handle human speech. The microphone consists of a laser interferometer, which can detect small displacements of photons, attached to a mirrored membrane. When sound vibrates the membrane, entangled photons are displaced and the measurements of this are converted to an electrical signal corresponding to the sound.

"When you use quantum light with entangled photons, you can measure these displacements a bit more precisely with a better signal-to-noise ratio," says Kaiser.

He and his team recorded spoken five-word sentences in German using their microphone and a classical microphone that also uses a laser interferometer. When they played these samples to 45 people at progressively lower volumes, 71 per cent of the volunteers could understand the quantum-recorded words for longer (*PRX Quantum*, doi.org/h2dk).

"When you use quantum light with entangled photons, you get a better signal-to-noise ratio"

The higher cost of the quantum microphone means it is unlikely to see practical use soon, especially given how effective even cheap standard microphones are, but a similar technique could create a quantum microscope for high-resolution biological imaging, says Kaiser.

Alex Wilkins

Space

Enormous impact flash lights up Jupiter's atmosphere

Leah Crane

ASTRONOMERS have spotted a bright flash from a huge space rock slamming into Jupiter. This impact flash, seen in October 2021, was the brightest one since comet Shoemaker-Levy 9 hit the planet in 1994.

Impact flashes on other worlds are similar to meteorite strikes on Earth, but only the largest are visible from afar. Observing how these events affect other planets can help us understand what will happen to Earth's atmosphere when similar-sized meteorites hit our world.

Ko Arimatsu at Kyoto University in Japan and his colleagues spotted the flash in 2021 using the Planetary Observation Camera for Optical Transient Surveys, a small telescope that is dedicated to looking for the light from impacts on Jupiter.

"All of the previous impacts detected by ground-based observations were achieved by amateur astronomers," says Arimatsu. "This is the first detection by a dedicated telescope."

The researchers found that the collision released an amount of energy equivalent to about 2 million tonnes of TNT, which indicates that the space rock that hit Jupiter had a mass of about 4000 tonnes (arxiv.org/abs/2206.01050).

The temperature of the flash was about 8000°C. An impact like this on Earth could cause burning damage from the flash in addition to destruction from the collision, so understanding the temperatures of impact flashes could help us know what to expect should such a large object ever head our way.

"We found that the expected rate of such impacts on Jupiter is about once per year, 100 to 1000 times more frequent than that on Earth," says Arimatsu. This should make studying them on Jupiter far easier than studying them on Earth, he says – not to mention safer.

Analysis Cryptocurrency

El Salvador's crypto gamble goes sour

The Central American nation has blown vast sums on a grand plan to build its economy around bitcoin, reports **Luke Taylor**

BITCOIN, the world's most popular cryptocurrency, has shed $1 trillion in value in two months as investors rush to sell amid fears that an asset bubble is bursting.

For El Salvador, which staked its economy on the success of bitcoin when it became the first country to make cryptocurrency legal tender in September 2021, the crash has wiped out more than half of its bitcoin holdings – and could be the death knell for its national crypto experiment.

El Salvador has invested heavily in creating and promoting the bitcoin infrastructure that president Nayib Bukele said would help Salvadorans access banking, save money on international payments and boost the economy. Yet most have shunned the cryptocurrency, preferring to continue using the US dollar.

The Central American nation also spent an estimated $105.6 million of taxpayers' money on bitcoin in the hope that its value would rise. Each time this has dropped, Bukele has bought more, live-tweeting the purchases. With the cryptocurrency's value now 70 per cent below its November 2021 peak, $58.1 million is believed to have been wiped out.

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A protest against the bitcoin law in San Salvador in 2021

MARVIN RECINOS/AFP VIA GETTY IMAGES

El Salvador's minister of finance Alejandro Zelaya told a press conference on 13 June that the risk of the bitcoin fund was "extremely minimal" and that the country hasn't lost anything as it hasn't yet sold its holdings.

70%

Drop in bitcoin's value since November 2021

"Forty-million dollars does not even represent 0.5 per cent of our national general budget," said Zelaya.

But the drop in value is a vast sum in a low-income nation of 6.5 million people with growing debt and an economy less than a hundredth of the size of the UK's.

The Salvadoran government won't publish its spending on bitcoin, but the cost of buying it, rolling out bitcoin ATMs and developing software probably amounts to at least $200 million, says David Gerard, author of *Attack of the 50 Foot Blockchain*.

"Blowing $200 million would be like the US blowing $200 billion," he says. "People will feel it. But also, it hasn't just blown that money. Bukele has alienated the World Bank, the IMF and all the other people he needed to borrow the money from to pay his bills."

As El Salvador's bitcoin gamble fails, economists increasingly fear that the nation is heading for a default. Its credit rating has been consistently downgraded since it embraced bitcoin and its debt payments are being bought with a heavy price discount as investors fear it can't make them, Bloomberg reports.

Prior to the latest price crash, El Salvador's national bitcoin push was already failing. A study published in May found that most Salvadorans abandoned the national bitcoin wallet after receiving a sign-up bonus and most who continue to use it trade dollars, not cryptocurrency.

The price crash could be the final nail in the coffin for bitcoin in El Salvador, says Oscar Salguero, a software developer from San Salvador. "Now the price of bitcoin is coming down quickly, even less people will use it."

Salguero says the money lost on bitcoin should have been used to address poverty or a series of national crises. El Salvador is currently mired in severe floods and a draconian crackdown on drug gangs that has left nearly 2 per cent of the country's adult population behind bars.

Some Salvadorans have said that even if bitcoin's value continues to tumble, Bukele, an ex-marketer who has staked his image as a tech-savvy messiah on his cryptocurrency gambit, is unlikely to turn back. "They are never going to accept that they have failed on this," says Mario Gomez, a developer who was detained by police for criticising the bitcoin law.

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Animal Welfare is an issue for all generations – young and old. Research carried out by YouGov revealed that 78 percent of people thought that animal welfare should be on the school curriculum. The League of Animals was developed to meet this need to help create a more curious younger generation and educate them about the environment and world in which we live in.

The League of Animals is a free educational resource designed by teachers for teachers. Its aim is to develop a sense of awe and wonder of our natural environment and everything that lives in it.

The online educational programme provides free educational resources for Key Stages 1, 2 and 3 and focuses on meeting specific requirements of the Science National Curriculum.

Created to stimulate curiosity and engage future generations in conservation, wildlife, habitats, landscapes, eco systems and natural resources discussions, the materials enable learners to interact and explore different topics, from the importance of bees, life cycles and human impact. Resources range from 10-60 minutes activities to ensure teachers can find suitable materials for their class plans.

The materials have a clear simple layout which has the teachers needs at the centre of the materials. Lesson plans vary from class based to practical tasks enabling children to experience a blended learning approach. The lesson plans help teachers meet the Science National Curriculum, but they also allow teachers to supplement other subjects such as Maths, Philosophy and Literacy creating a truly engaging learning environment.

Want to get involved?

To view and use the materials, which can be used in classes or as standalone resources for children home educated, please visit www.leagueofanimals.org.uk. By educating children about the importance of animals and the world in which we live, we hope to create a more curious compassionate generation of animal advocates.

Do you need your signal boosted?

If you are a charitable organisation working in STEM, science, medicine, technology or conservation, and would like to find out more about this project contact Jacqui McCarron on jacqui.mccarron@newscientist.com

Geology

Underwater volcanic world

A photographer has documented volcanic activity under the sea

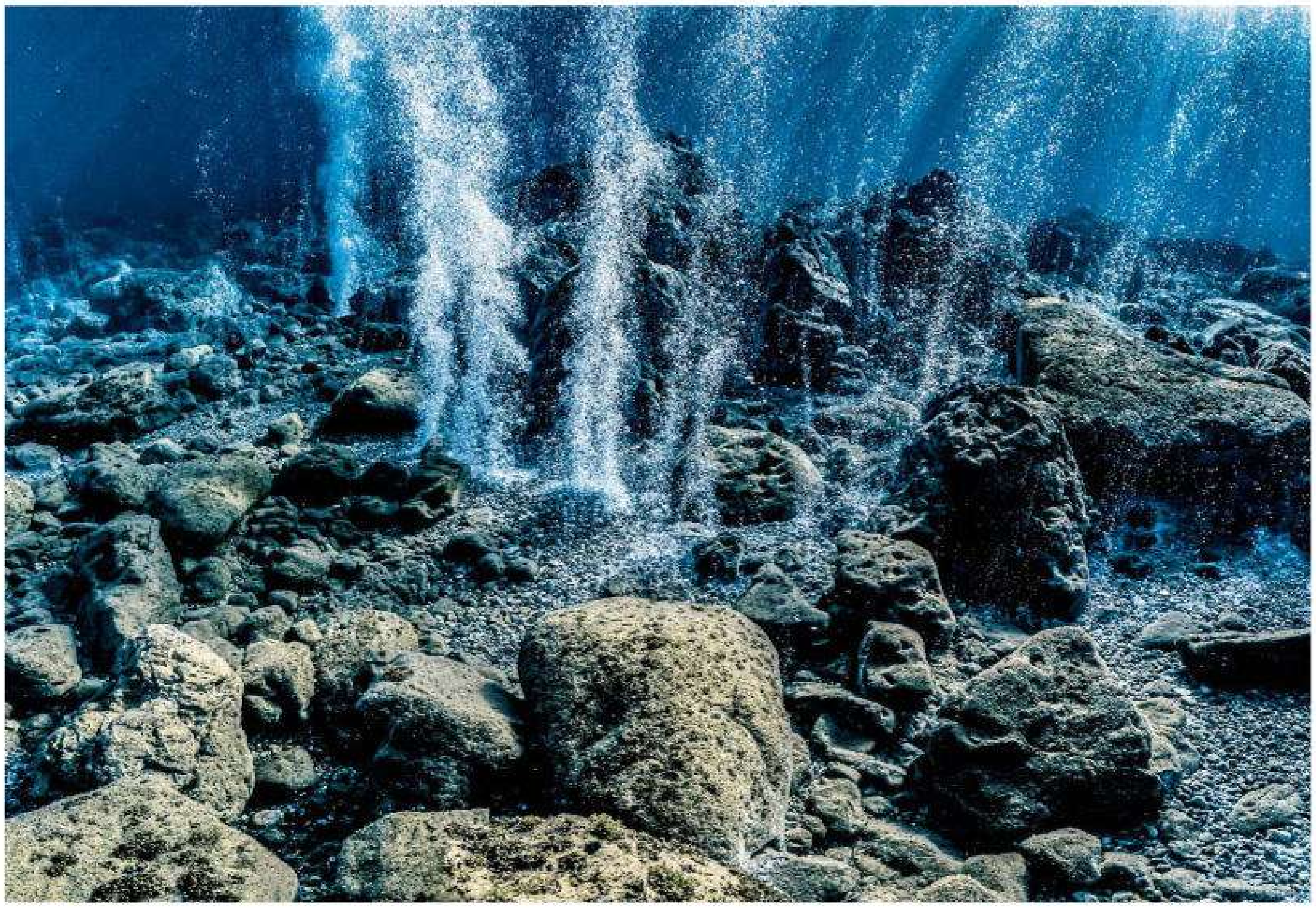
Carissa Wong

HYDROTHERMAL vents spew acidic fluids and bubbles into the sea in a photograph captured at Panarea, a volcanic island near Sicily, Italy. The image was taken as part of 1 Ocean, a project by photographer Alexis Rosenfeld in partnership with UNESCO.

Rosenfeld's guide at Panarea was researcher Francesco Italiano, who monitors underwater volcanic activity in the Aeolian Islands, including Panarea, to determine whether potentially dangerous eruptions are imminent.

Researchers regularly dive to observe and sample these curtains of bubbles that come from magma reservoirs below Earth's crust.

"When you dive over an active volcano, the feeling is totally different to any other dive," says Italiano. "You feel your skin burning because of the hot water and the acidic compounds, but it's a lovely burning."



ALEXIS ROSENFELD - UNESCO - @1OCEAN_EXPLORATION

Technology

Working in virtual reality cuts productivity

PEOPLE working full-time in a virtual-reality environment have lower productivity and well-being, and increased anxiety, according to a new study.

The research shows that, despite companies such as Microsoft and Facebook owner Meta investing heavily in VR and the immersive virtual world of the metaverse, the technology isn't yet ready for widespread deployment in the workplace, and some people may never be able to use it effectively.

Jens Grubert at Coburg University in Germany and his colleagues, including researchers at Microsoft, recruited 10 men and six women, with an average age of 29, to work a five-day week while wearing an Oculus Quest 2 VR headset, and another full week using a conventional computer. They worked 8-hour days with a 45-minute lunch break. Those participation figures don't include two people who dropped out on the first day because of migraines and nausea.

The 16 people who lasted for the whole trial reported 42 per cent higher frustration using the VR headset, 19 per cent more anxiety and 48 per cent more eye strain. They also reported 16 per cent lower productivity, 20 per cent lower well-being and found the VR system 36 per cent less usable than a conventional set-up (arxiv.org/abs/2206.03189).

Nonetheless, there are benefits to working in virtual reality, says Grubert. The headset means users can pan between as many virtual monitors as they like simply by moving their head. It also allows remote colleagues to interact in a virtual space as if they were in the same room, and the environment can be tailored to requirements.

But on the negative side, current headsets create a view with relatively low resolution, can be heavy to wear for long periods and the disorientation of receiving different visual and balance inputs can be unsettling and cause nausea.

"VR can emulate great working environments, so firms may care less about physical spaces"

Grubert says regulation is needed to protect workers from being forced to use VR. He also says that "in VR, you can emulate great working environments", so firms may care less about the physical spaces they put staff in.

The future of on-site and remote work requires a more flexible management culture than just technological improvements, says Grubert. "If people can work more confidently and have a better productivity and well-being at home, then let them work there with whatever technologies they find usable," he says.

Matthew Sparkes

Geophysics

Pollution from rockets could affect weather systems

Jonathan O'Callaghan

AS MORE and more rockets are launched into space, the pollution they emit could have a growing effect on Earth's atmosphere.

Many rockets today use kerosene, which is burned with an oxidiser – liquid oxygen – to produce thrust. A by-product of this process is black carbon, soot-like grains thrown out in the exhaust. Previous work has shown that black carbon can remain in the stratosphere for up to five years, trapping heat from the sun.

Christopher Maloney at the National Oceanic and Atmospheric Administration in Boulder, Colorado, and his colleagues modelled what sort of atmospheric effects we might expect if launch rates increase to 10 times their current level by 2040, in line with today's trends.

They found stratospheric temperatures could rise by up to 1.5°C in such a scenario, while jet wind speeds could decrease by 5 metres per second. These changes could affect the movement of high-pressure weather systems, particularly in the tropics, where most launches take place. As a result, larger amounts of black carbon are concentrated in these regions and this may slightly change the paths of tropical storms. There could also be a small depletion in ozone levels (*JGR Atmospheres*, doi.org/hz68).

Eloise Marais at University College London says there is reason to worry. "The scenario they investigate is plausible," she says. "The effect on the stratosphere is concerningly high."

SPACEX/ZUMA WIRE/SHUTTERSTOCK

A kerosene-burning SpaceX Falcon 9 rocket launch

Gene editing

Younger children to try CRISPR therapy for sickle cell disease

Michael Le Page

CRISPR gene-editing trials for treating sickle cell disease and beta thalassaemia are being extended to include children aged under 12, after the therapies proved successful in ongoing trials involving people aged 12 to 35. The aim is to treat children early enough to prevent them getting lasting damage from these inherited conditions.

"The results are superb," says Josu de la Fuente at Imperial College London, a doctor who is involved in the trials, which include patients from multiple sites across the European Union, UK and US.

Making the treatment widely available will be a challenge, though, because of its cost, which could be an issue even in rich countries, says de la Fuente.

The CRISPR therapy used, called exa-cel, was developed by CRISPR Therapeutics and Vertex Pharmaceuticals. The two companies previously reported promising initial results from the first few people that were treated.

They have now announced results from phase II trials testing the effectiveness and safety of the approach in 75 people. The results were presented on 12 June at a meeting of the European Hematology Association.

Beta thalassaemia and sickle cell disease are caused by genetic mutations that affect the adult form of haemoglobin, the molecule that carries oxygen in the blood.

Some people get few if any symptoms despite having one of the mutations that normally causes these conditions because their bodies keep producing fetal haemoglobin into adulthood.

SCIENCE PICTURE CO/ALAMY

Sickle cell disease changes the shape of red blood cells

The treatment aims to mimic this by extracting blood-producing stem cells from people's bone marrow, using CRISPR gene editing to disable the gene that turns off fetal haemoglobin production and then putting the edited cells back into each person.

The 44 people with beta thalassaemia in the trial all required regular blood transfusions before the treatment. Now, 42 of them no longer need transfusions, with the benefits persisting as long as people have been followed up – more than three years in some cases. The other two people no longer need to be given as much blood as they did before.

Another 31 people had severe sickle cell disease and, on average, had four vaso-occlusive crises a year, in which abnormal red blood cells block the blood supply to tissues. These episodes can result in lasting damage and severe pain. None of the 31 have had such episodes since being treated between two months and about two-and-a-half years ago.

"The results are a remarkable achievement for CRISPR therapy," says Gaetan Burgio at the Australian National University. However, the full details of the study do still need to published, he says.

Some people with sickle cell disease or beta thalassaemia are already treated by giving them bone marrow transplants, but finding suitable donors isn't always possible and using a person's own cells instead would avoid some potentially serious complications of transplants.

Conventional bone marrow transplants and the CRISPR treatment both have a major drawback. People's existing blood stem cells have to be killed by chemotherapy to make room for the replacement ones, which can have side effects including infertility, says de la Fuente. He hopes safer ways of killing blood stem cells involving antibodies rather than chemotherapy will become available soon.

75

The number of people enrolled into latest CRISPR therapy trials

Both approaches are also expensive and require many highly trained personnel. This will make it difficult to roll out the gene-editing treatment to the millions who could benefit worldwide.

The team is exploring whether blood stem cells could be gene-edited inside the body instead, says de la Fuente. Such an "off-the-shelf" solution would make the treatment easier to deliver at scale, but this work is still at a very early stage.

Solar system

Ancient meteorite overturns our ideas of how Mars formed

Alex Wilkins

A METEORITE that landed on Earth more than 200 years ago is upending our ideas of how Mars formed. A new analysis of it reveals that the interior chemical make-up of the Red Planet largely came from meteorite collisions, rather than from a cloud of gases as was previously thought. This makes Mars's early formation similar to that of Earth.

Most of what we know about Mars's mantle, the section of rock outside the planet's core, comes from three Martian meteorites – Shergotty, Nakhla and Chassigny – that crashed to Earth after being blasted off Mars by impacts.

Previous analyses of Chassigny, which landed in France in 1815, looked at isotopes of xenon, a chemically inert gas that can survive unchanged for millions of years. These isotopes – atoms that differ by their number of neutrons – occur in specific ratios that can be tied to a place and time.

The isotope ratios from the meteorite seemed to match those of both Mars's atmosphere and the solar nebula, a large cloud of gas from which the primitive solar system formed. This led to the hypothesis that the Red Planet's volatile elements, such as hydrogen, carbon and oxygen, came from the solar nebula and that additional elements came from meteorites later.

VALUGI/WIKIPEDIA CC BY-SA 4.0

A piece of the Chassigny meteorite, which has now been reanalysed

Now, Sandrine Péron at ETH Zurich in Switzerland and Sujoy Mukhopadhyay at the University of California, Davis, have analysed a sample from Chassigny to look at isotopes of krypton – another inert gas – by using a high-resolution mass spectrometer.

"With xenon isotopes, it's difficult to distinguish the precise source of volatiles, but that's not the case with krypton," says Péron. "With krypton, you can better see the difference between potential sources, like from solar or meteorites… but krypton isotopes are more difficult to measure than xenon isotopes, so that's why it had not been previously done."

The researchers found that the isotopes came from meteorites rather than from the solar nebula (*Science*, doi.org/gqcdw8).

This also implies that the Martian atmosphere, which contains mainly solar nebula isotopes, wasn't created by gases exuding from the mantle as we previously thought, says Péron. So where did those atmospheric gases come from? It could be that they were trapped in the ground closer to the surface, or in the cold polar caps if the young Mars grew quickly, and are being gradually released by impacts, says Péron.

The work could fundamentally change our picture of how Mars was formed, as well as shore up our understanding of planetary formation in our solar system, in which Mars seemed an outlier.

"It's a major change in our understanding of the origin of volatiles in Mars," says Chris Ballentine at the University of Oxford. "The end result is that Mars looks much closer to the way the Earth formed and the way that Earth acquired volatiles, which gives us a much more consistent view of how planets acquire their volatile elements."

1815

The year the Chassigny meteorite crash-landed in France

Finding out how volatile elements are acquired and distributed is also essential for understanding a planet's chemical make-up, says Ballentine. "The timing and source of the volatiles controls the oxidation state, which, in turn, controls the structure and distribution of elements in the planet, which for our own Earth is why we can live on it." ▮

Technology

Global satellite map will help hunt down illegal fishing vessels

ABOUT 20 per cent of the global seafood catch is harvested illegally, but it might be possible to clamp down on that now an online map using satellite radar can spot where boats are operating incognito.

Commercial-size vessels must usually have Automatic Identification System (AIS) transponders so they can be tracked. However, fishing boats can hide by simply turning off their AIS.

Satellite-based radar can be used to find ships without their AIS turned on, and in 2020 the Global Fishing Watch (GFW) non-profit group used satellite data to detect a "dark fleet" fishing in North Korean waters. But it was only possible to focus on small areas.

Now, more affordable processing makes global oversight possible, says David Kroodsma at GFW.

Instead of asking humans to spend hours looking through specific satellite images, "we can use computer-vision algorithms to look through every single satellite image we record in a matter of minutes", says Jared Dunnmon at the US Department of Defense's Defense Innovation Unit, which has been working with GFW.

GFW processed AIS data to get known ship locations, then sifted through petabytes of information from the European Union's two Sentinel-1 radar satellites to extract the signatures of vessels in coastal waters. Comparing the two data sets revealed where vessels are operating without AIS switched on.

> "We can use computer-vision algorithms to look through every single satellite image in minutes"

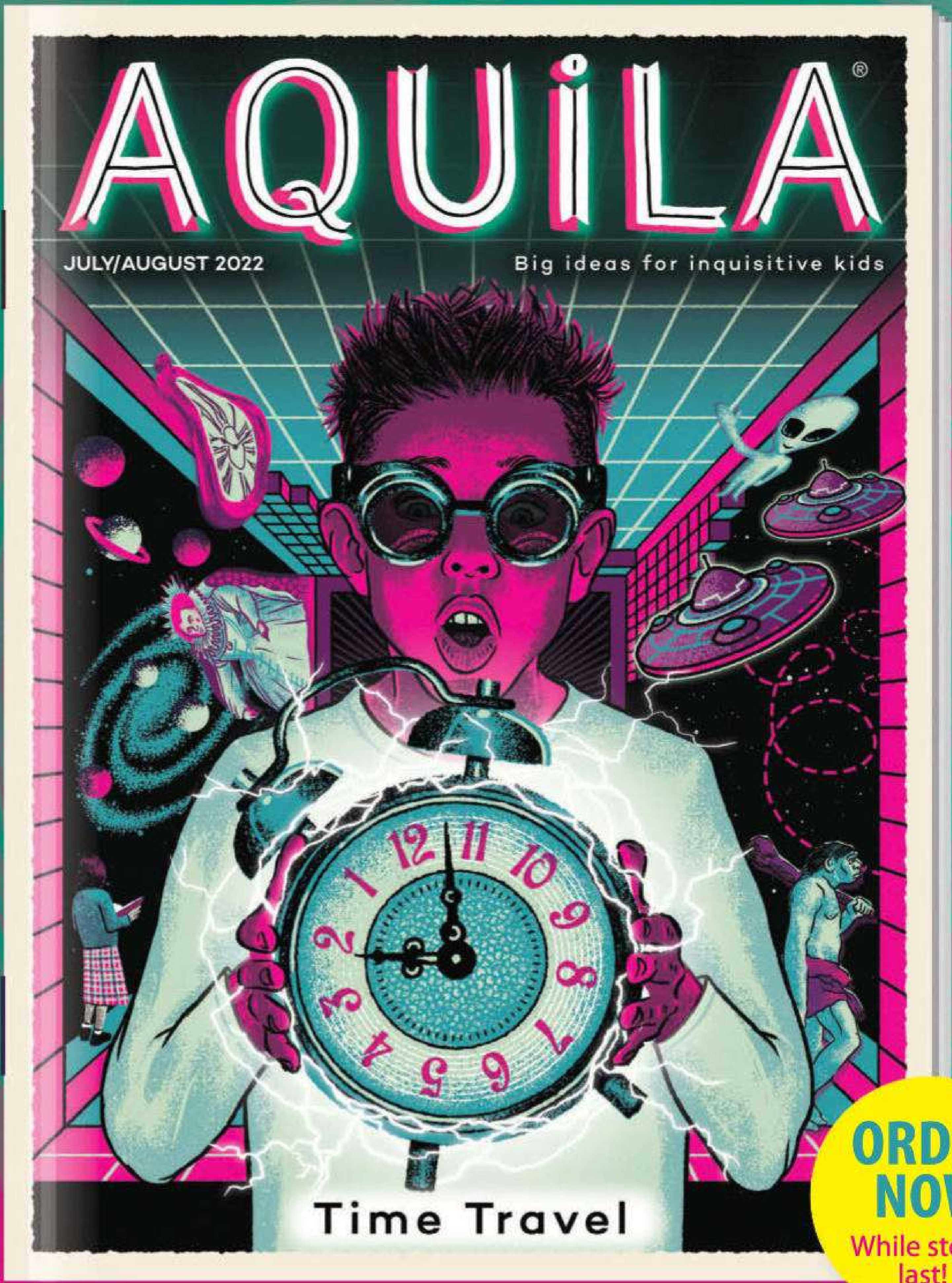
"We have processed about six years' worth of data," says Kroodsma, and "are currently showing data from 2022."

The map allows viewers to zoom in to see activity by incognito vessels across the globe. A vessel not broadcasting its position isn't necessarily engaged in illegal activity, though, says Kroodsma.

The map could help coordinate efforts against illegal fishing and tell law enforcement where to patrol, says Steve Trent at the Environmental Justice Foundation. ▮

David Hambling

Award-winning Children's Magazine



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LUIZ F. RIBEIRO

Animal behaviour

Tiny jumping frogs lack balance to stick the landing

PUMPKIN toadlets – miniature frogs native to Brazil – are woefully clumsy jumpers, unable to control their landings. Research suggests that this is down to the tiny inner ear canals that guide their balance.

Some relatively primitive frog families, like New Zealand frogs and tailed frogs, don't have controlled landings when jumping, says Richard Essner at Southern Illinois University Edwardsville. But when collaborators in Brazil found that the 1-centimetre-long pumpkin toadlet (*Brachycephalus sp.*) was similarly ungainly, it came as a surprise, since it isn't closely related to the other frogs.

Essner suspected it was to do with the frog's diminutive size. As the semicircular canals of the inner ear get smaller, the fluid inside doesn't flow as easily. This causes reduced sensitivity to changes in the body's rotation.

To see how this might affect landing posture, Essner and his team made three-dimensional X-ray scans of the canals of 147 frog and toad species, across the full size range of living species. They found that *Brachycephalus* frogs have the smallest canals known from any vertebrate.

High-speed video analysis of jumping pumpkin toadlets revealed that the change in rotation speed was lowest in the "flight" stage of the jump. This means that, with their insensitive ear canals, the toadlets may find it hardest to track and control how their bodies are moving in this phase, and end up in the wrong orientation when they come to land (*Science Advances*, doi.org/gqcc5b). **Jake Buehler**

Health

Genes give clue to your covid-19 risk

MORE than 1000 genes may contribute to an individual's risk of developing severe covid-19, on top of factors such as age, ethnicity and any health conditions.

Most of the genes, discovered in a study of more than 1 million people, affect the functioning of two kinds of immune cell.

If the results are confirmed, they could help devise a test that assesses a person's risk of getting badly ill with covid-19, says Johnathan Cooper-Knock at the University of Sheffield, UK.

Cooper-Knock and his team used artificial intelligence to analyse results from a global data set called the COVID-19 Host Genetics Initiative. They looked at which genetic variants were more common in about 5100 people who died or needed respiratory support because of covid-19, compared with about 1.4 million people who never tested positive for the infection. None of the participants were vaccinated.

They found 1370 gene variants linked to covid-19 severity, with these coming up again when checked against two similar data sets. These variants accounted for three-quarters of the participants' genetic risk for severe covid-19.

Next, the results were cross-checked with information on which genes are normally active in 19 different types of cell in healthy lungs. This showed that immune cells called natural killer cells and T-cells are key in controlling whether covid-19 becomes severe (*Cell Systems*, doi.org/gqb4mb).

Before the results can be turned into a commercial genetic assay to assess risk, a prototype would need to be tested further, says Cooper-Knock. Such a test may be less accurate if used on vaccinated people, as genetic susceptibility is less relevant if you have a vaccine, says James Davies at the University of Oxford. **Clare Wilson**

Solar system

Moon samples are drier than expected

WATER has been found in samples of moon dust and rocks returned by China's Chang'e 5 mission, but not as much as expected.

Chang'e 5 landed on the moon on 1 December 2020 and collected lunar soil and rocks. Two days later, an ascent stage lifted off the moon, bringing the samples back to Earth about two weeks later. Jianjun Liu and Bin Liu at the Chinese Academy of Sciences and their colleagues have now analysed these and found signs of water bound up in their mineral structure.

SHUTTERSTOCK/PAITOON PORNSUKSOMBOON

They found that the lunar soil had levels of water around 28.5 parts per million – relatively dry, even for the moon. However, pieces of the mineral apatite in the sample had up to 179 parts per million (*Nature Communications*, doi.org/hz7n).

"The amount of water observed is kind of on the low side of what we would have expected," says Parvathy Prem at Johns Hopkins University in Maryland, who wasn't involved with this work. That may be because Chang'e 5 took samples during a particularly warm time of day. Or it could be because the craft landed in an area protected by Earth's magnetic field from the solar wind. This wind contains hydrogen that can become water when it meets oxygen atoms on the moon's surface, a known source of lunar water. **Leah Crane**

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Really brief

SHUTTERSTOCK/NILS JACOBI

Chewing catnip may be beneficial to cats

Catnip contains a chemical that works as a natural mosquito repellent, and by chewing the plant's leaves, cats can increase emissions of it 10-fold. The discovery may help explain why cats chew, but don't swallow, the plant (*Nepeta cataria*). However, it could also be a coincidental benefit (*iScience*, doi.org/gqb37p).

We may have found Black Death's origin

One of the deadliest pandemics in history may have begun in what is now Kyrgyzstan. DNA from plague bacteria (*Yersinia pestis*) has been uncovered from three human graves there dating to 1338 – eight years earlier than known records of the disease (*Nature*, doi.org/gqb8vp).

Polar bears adapt to hunt without sea ice

Sea ice, which polar bears use as a platform from which to hunt seals, is rare in south-east Greenland. But bears in the region are surviving by hunting from freshwater ice released by glaciers instead, suggesting the animals may be more resilient to sea ice loss due to warming than thought (*Science*, doi.org/gqcdw9).

Fossil fuels

BP stock unscathed by spill in long term

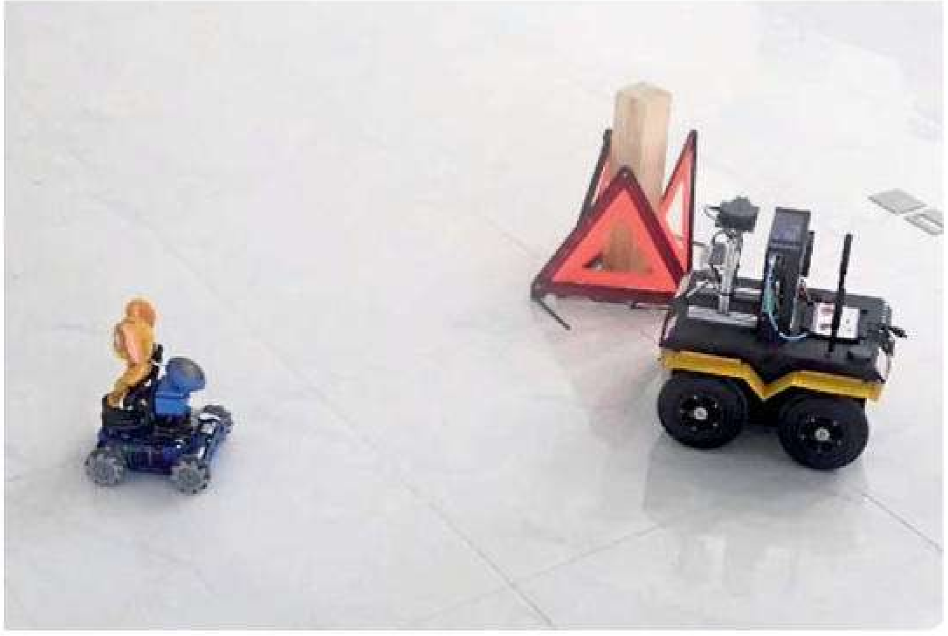
THE Deepwater Horizon marine oil spill, the largest in US history, had no impact on long-term stock market returns for BP, compared with a simulation of the firm in which the disaster never happened.

It has been hard to quantify some consequences for BP after the 2010 spill of 800 million litres of oil into the Gulf of Mexico. That is because of the lack of a control against which to compare the firm's stock market performance and reputation. To fill the gap, Aseem Prakash at the University of Washington in Seattle and his team created "synthetic" versions of the company from 2010 to 2017.

To measure reputation, the team built the alternative BP out of a weighted average of 15 other brands, including Shell, using rating perceptions from positive (+100) to neutral (0) to negative (-100). The real BP dropped more than 50 points below its simulated version just after the disaster compared with the counterfactual version. By 2017, it had stabilised at only 17 points below its disaster-free peer.

A similar approach was used to assess stock market performance, using a weighted average of 187 companies in the S&P 500 stock market index at the time of the disaster. While the real firm's share price dipped dramatically in the two months after the spill, there was no significant difference between it and the synthetic BP either one to two years after the spill or two to seven years after (*PLoS One*, doi.org/gqb9b2). BP didn't comment on the research.
Adam Vaughan

Technology



MA ET AL., SCI.ROBOT.7,EABK2948

Brain-like AI chip enables a robo game of cat and mouse

A MACHINE game of cat and mouse in a lab provides a peek at a future in which robots carry out search-and-rescue missions or wildlife surveys without much human guidance.

The Tianjicat robot developed by researchers at Tsinghua University in China uses a brain-inspired computing chip called TianjicX. The so-called neuromorphic chip can run multiple artificial intelligence techniques simultaneously in an energy-efficient manner.

The team challenged the Tianjicat robot to chase another robot that was set to move randomly in a room filled with obstacles (pictured). Tianjicat tracked the mouse robot via visual recognition and sound detection, figuring out the best path to take without colliding. Its chip reduced the amount of power required for the robot cat to make decisions during the chase by about half compared with an NVIDIA chip designed for AI computing (*Science Robotics*, doi.org/gqcc5v).

Doing this would be a step up in difficulty for most commercial robots. Many robots that interact with more complex environments rely on remote control by people, or maintain wireless connections with data centres with the computing power needed for more intensive decision-making. **Jeremy Hsu**

Biology

Natural drug reduces eating in obese mice

AN ALTERED form of an amino acid produced in both humans and mice after exercise can help obese mice lose weight by curbing their appetite. It could lead to a new treatment for obesity.

Lac-phe is produced when the amino acid phenylalanine reacts with another molecule called lactate, although its exact role in the body was unclear.

Yong Xu at the Baylor College of Medicine, Texas, and his team have now found evidence that lac-phe reduces the appetite of mice after exercise. Xu and his team analysed the blood of five mice that had run to exhaustion on a treadmill and found the level of lac-phe increased more than that of any other molecules produced as a result of the exercise.

They then injected 12 mice that were obese with either lac-phe or saline daily for 10 days. The team found that the mice given lac-phe ate half as much food as the control mice within the 12 hours after the first injection, leading to a significant loss of body weight by day eight. The team also gave lean mice lac-phe and found food intake wasn't affected, suggesting the molecule only suppressed appetite in obese mice (*Nature*, doi.org/hz66) **Carissa Wong**

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Jacob Aron dives into the creepy world of video game *Silt* p36

Comment

Polluted partnerships

Elite universities must urgently end their cosy relationships with the fossil fuel industry, says **Zak Coleman**

MICHELLE D'URBANO

UNIVERSITIES like Cambridge enjoy a special status in society. They are celebrated as bastions of excellence, academic integrity and independent research. They claim to be deeply committed to young people and their futures.

Ten months into my term as undergraduate president of the Cambridge Students' Union, I believe my university is betraying these ideals. While its leadership talks up climate action, the university also maintains research and sponsorship partnerships with fossil fuel giants that must surely still be contributing to climate catastrophe.

It may have announced in 2020 that it would divest its multibillion pound endowment fund from fossil fuel-linked holdings, but Cambridge accepted £14 million in donations from oil giants between 2017 and 2021. As of now, it still hosts a BP Institute, recently occupied by more than 40 protesting students and academics, and a Schlumberger Research Centre – both of which do work on fossil fuel extraction. There is also the Cambridge Shell professor of chemical engineering whose research currently includes oil extraction techniques, BP and ExxonMobil academic prizes and even BP-branded lab coats and Shell workbooks for some science students.

As more than 700 academics argued in an open letter this year, these ongoing public associations with globally revered scientific institutions act as a shield against efforts to expose fossil fuel giants' seemingly wilful disregard for the overwhelming scientific consensus, frontline community suffering and young people's future, ultimately helping to delay political action against them.

The millions on offer might be very tempting, but the fact is that these firms stand against everything universities claim to hold dear. After all, a number of fossil fuel giants have spent more than 50 years trying to obscure and discredit university-produced climate science. And they continue to lobby against basic, science-led climate legislation.

It isn't just Cambridge. Between 2017 and 2021, UK universities accepted £89 million in donations from oil giants alone. Nor is it just a UK issue. Most recently, a new sustainability institute at Stanford University in California sparked a backlash after stating its willingness to work with and accept funds from fossil fuel firms. Globally, by accepting such arrangements, elite universities continue to greenwash the fossil fuel industry on a shocking scale.

Cambridge now says it only accepts fossil fuel cash for funding climate solutions research. This totally ignores its pre-existing research partnerships focused on expanding fossil fuel extraction.

Even if we swallow the line that multibillion pound universities with enormous philanthropic fundraising capacity can't find funding alternatives, they can no longer ignore the glaring conflicts of interest inherent in partnering with fossil fuel companies for research aimed at addressing a climate crisis that those firms are driving. It would be very difficult to consider climate-related research to be independent when bankrolled by organisations still investing overwhelmingly in long-term fossil fuel expansion. It is the climate equivalent of tobacco industry funding for public health research – long since rejected.

Our universities have such a critical role to play in asserting the scientific realities of climate breakdown. We can't allow their integrity and independence to continue to be compromised through association with those pouring oil on the flames.

If universities' identities as moral leaders, defenders of the scientific method and guardians of young people's futures are to mean more than just words in a glossy prospectus, they must urgently end their cosy relationships with the fossil fuel industry. ▮

Zak Coleman is undergraduate president of Cambridge Students' Union, UK

This changes everything

Return of the encabulator

An 80-year-old meme that fondly satirises absurd technical language is still bringing engineers joy, finds **Annalee Newitz**, who is ready for the crypto version

Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

A COUPLE of weeks ago, I stumbled across a strange video on YouTube called "SANS ICS HyperEncabulator". In it, a suave man in a suit explained this new "cybersecurity" machine, gesturing at an impressive refrigerator-sized device, hailing its ability to be "sinosinclastic without sacrificing both normative reality and AI-informed modalities". He then explained that a previous generation of this device, the retro-encabulator, was made with "prefabulated amulite surmounted by a malleable logarithmic casing". Not so with the HyperEncabulator! Unlike its predecessors, he said, the HyperEncabulator "operates totally under the principle of colonic effluvium expulsion".

I had to know more. After a few searchulations and intertronular queries, I discovered that there is a rich history of encabulation. This technobabble satire actually started back in 1944, when a student named John Hellins Quick described a "turbo-encabulator" for the student journal of the British Institution of Electrical Engineers. Quick noted that the "two spurving bearings were in a direct line with the pentametric fan". That was important because "the latter consisted simply of six hydrocoptic marzelvanes, so fitted to the ambifacient lunar waneshaft that side fumbling was effectively prevented".

His engineering in-joke went viral – or at least the 1940s version of viral – when a *Time* magazine columnist referenced the turbo-encabulator in a 1946 article about new inventions. Amused readers sent in letters building on the joke, enquiring about the "dingle arm" and noting that "if the bearings are lubricated with warm smortch they will not grunch".

Throughout the encabulator's history, Quick's words have been used and reused – even in the HyperEncabulator pitch I saw from 2022. In nearly every retelling, we hear about avoiding "side fumbling" and learn about "prefabulated amulite". Many of the film versions include Quick's entire description, while adding their own embellishments.

The first known movie about this astonishing device came in the late 1970s. According to film-maker Dave Rondot, he and his crew had just finished making some corporate films for GMC Trucks in Detroit, Michigan, and were messing around in the studio with voice-over actor Bud Haggert. Haggert had made hundreds of industrial instruction films and was sick of reading technobabble, so he asked if Rondot would film him reading a script about what he called the "turbo-encabulator".

> **"It was inevitable that the joke would move into the realm of computers, full of highly technical but nonsensical claims"**

The result was hilarious. He describes a weird device with "prefabulated amulite" that had the astonishing ability to avoid all those pesky problems with "side fumbling". For nearly 2 minutes, he gestures at a drawing of what looks like some kind of fuel injector, extolling the benefits of its ability to "automatically synthesise cardinal grammeters" in a rich monotone. Not to be outdone, Chrysler quickly created its own version.

The people making these videos weren't engineers satirising engineering papers, they were communications specialists making fun of their corporate educational materials. And the corporations were in on the joke, allowing their brands to appear in these videos. Encabulator movies were a humblebrag, a way of showing off the company's technological prowess without seeming too elitist.

It was inevitable that the encabulator joke would move into the realm of computers. After all, the computer industry currently reigns supreme when it comes to highly technical but nonsensical claims about its products.

In 1997, electronics and software company Rockwell Automation created a "retro encabulator" video. Noah Rosenberg, who worked at Rockwell at the time, told me via Twitter that it was "the actor having fun, just blowing off steam". The film itself, he said, was an "early example of a meme... These things would get bootlegged on physical media, people who had two VCRs would make you a copy... Back then if 100 people saw something you made it was a hit." And the hit lives on. The SANS ICS video I saw was a direct sequel to Rockwell's retro encabulator video, even using the same actor.

What has fuelled this peculiar meme for almost 80 years? There is the obvious answer: engineers have a pretty good sense of humour about absurd technical language. But something else is being satirised too: the way that marketing often uses scientific-sounding phrases to trick people into buying things they don't need – especially if we are worried about side fumbling!

Most of the pitches I get for NFTs and crypto-coins sound like they are coated in prefabulated amulite. As long as we stay thirsty for scammy tech that promises us the world but gives us empty wallets instead, the encabulator will never get old. ▮

Annalee's week

What I'm reading

Spear, *an action-packed retelling of the Arthurian legend of Percival by Nicola Griffith.*

What I'm watching

Brideshead Revisited, *because I needed to understand the true meaning of sweater vests.*

What I'm working on

An article about a lab in Oregon where engineers create tsunamis in giant water tanks.

This column appears monthly. Up next week: Beronda L. Montgomery

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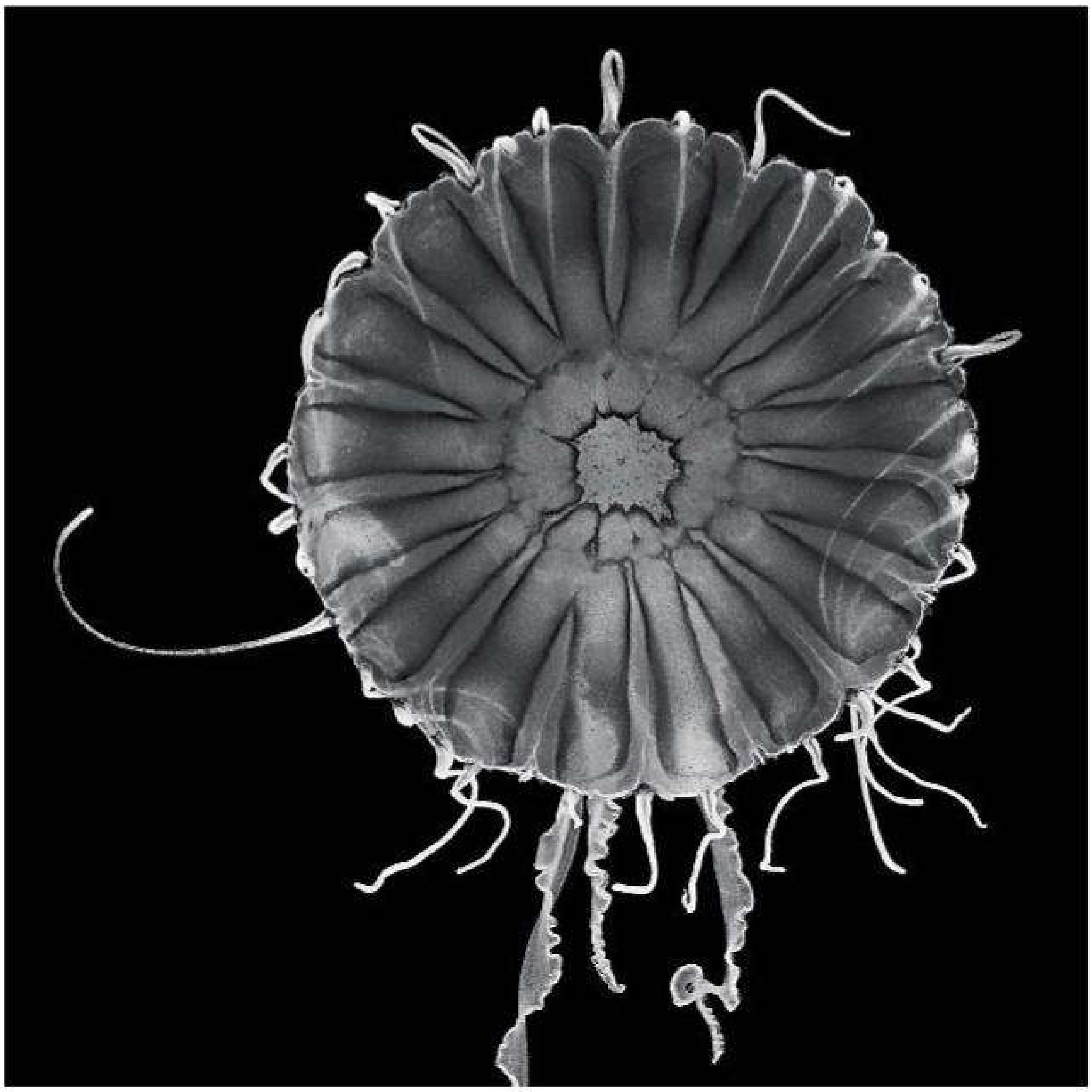

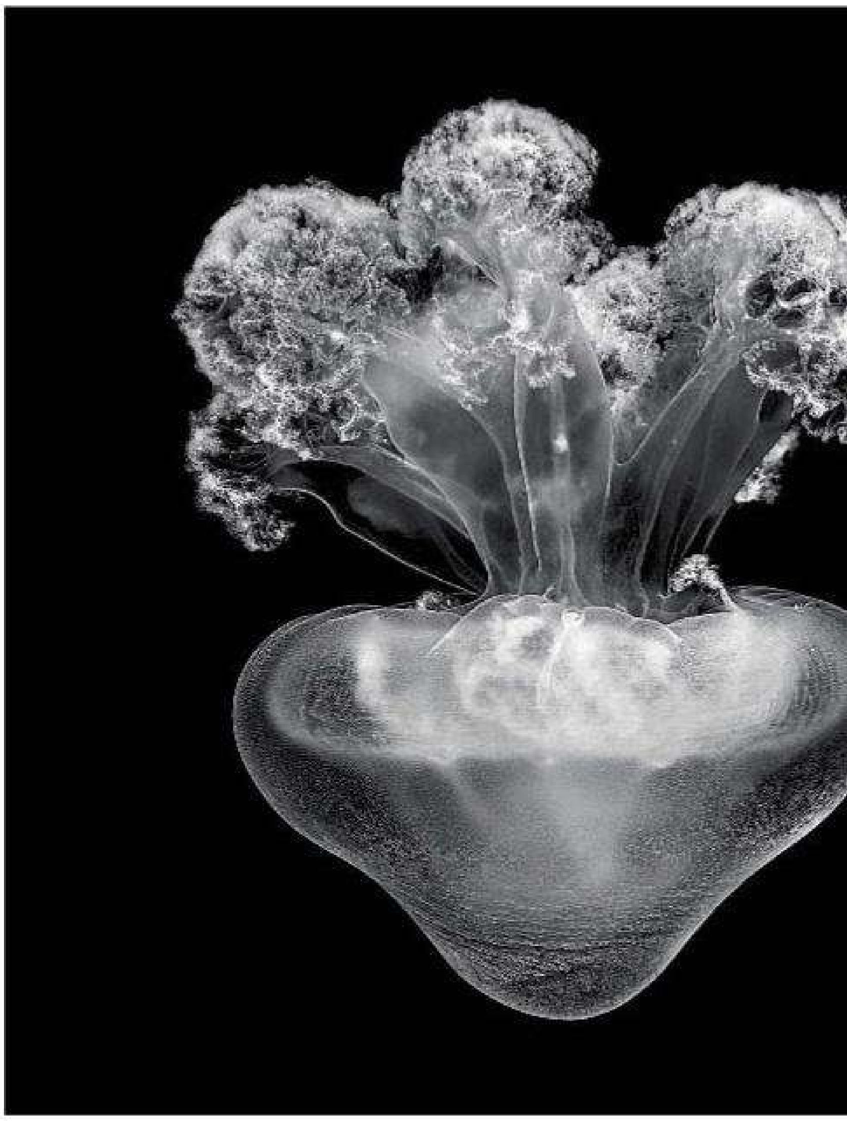

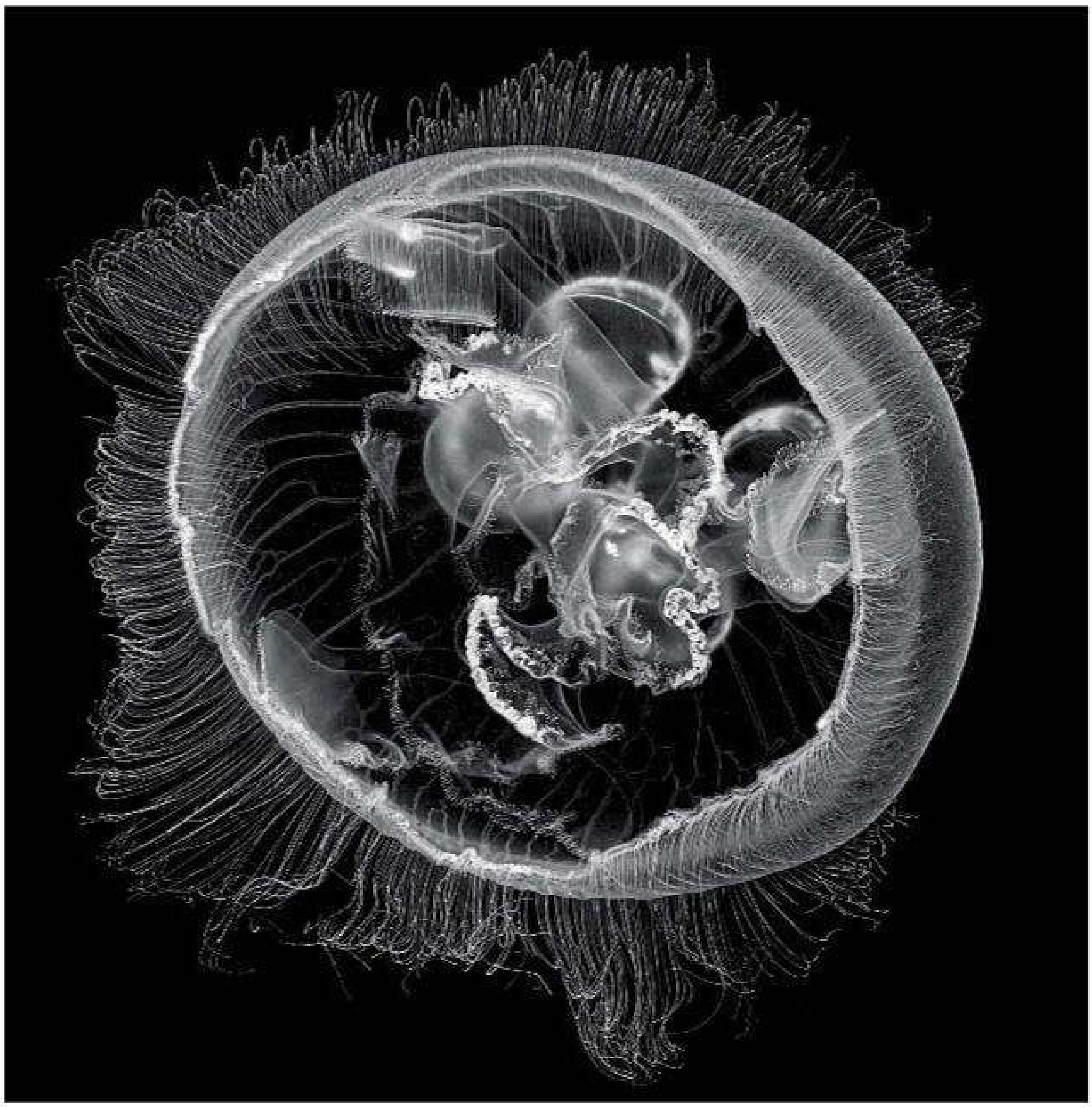

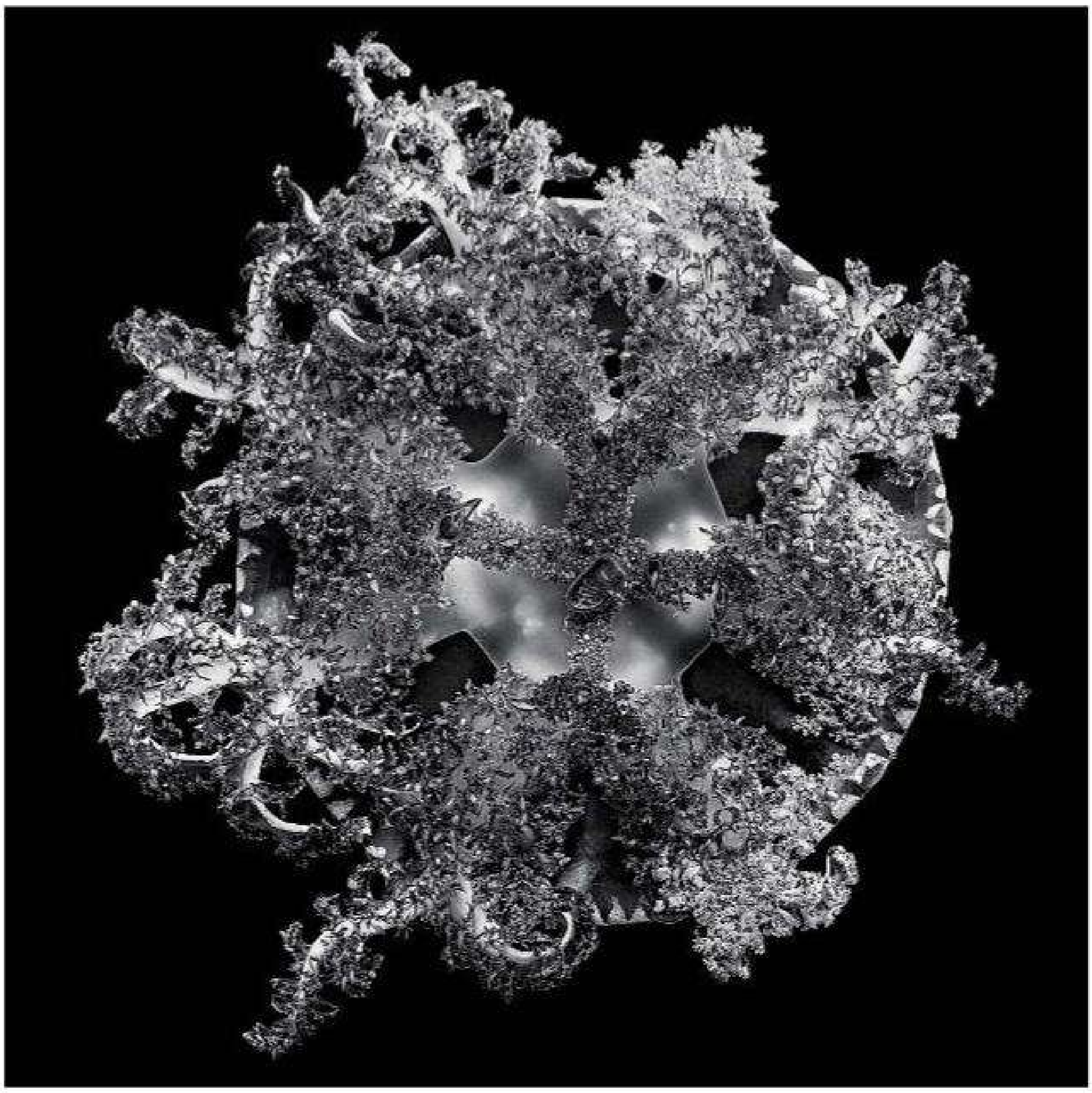

Aliens of the sea

Photographer **Jan Schlegel**

THESE striking prints capture the intrigue of one of the world's most enigmatic groups of animals: jellyfish. They form part of photographer Jan Schlegel's new project, *Of Aliens, Mermaids and Medusas*, a celebration of these prehistoric sea creatures.

Jellyfish are thought to have existed for 500 million to 700 million years, and despite lacking blood, bones and even a brain, they are remarkably complex. Some are even capable of feats such as resetting their life cycle, as is the case for the species *Turritopsis dohrnii* (also known as the immortal jellyfish).

The mysterious qualities of these invertebrates is what spurred Schlegel to choose them as a means to inspire creativity and stimulate the imagination. "I was watching the movements of a moon jellyfish in a tank for days and I realised it was absolutely fantastic," he says. "I realised this is not a jellyfish, this is a monster looking at me."

Schlegel shot these images of different jellyfish species at the jellyfish lab in the Two Oceans Aquarium in Cape Town, South Africa. He made the photographic prints using a process called platinum printing, whereby platinum salt emulsion is embedded into the paper fibres. The images are available as limited-edition handmade platinum prints from Schlegel.

The top row (left to right) shows the jellyfish species *Rhizostoma luteum (*plus a photobombing fish), *Phyllorhiza punctata* and *Aurelia coerulea*. The bottom row shows (left to right) *Chrysaora melanaster*, *Catostylus azani* and *Cassiopea xamachana*. ▮

Gege Li

Editor's pick

Causal emergence has opened Pandora's box

28 May, p 44

From Guy Inchbald, Upton-upon-Severn, Worcestershire, UK

Causal emergence – the idea that the cause of some events can't be found at the microscopic level – is revolutionary in more ways than one. The concept seeks to explain physical phenomena that can't be reduced to the current pillars of physics: relativity, quantum physics and thermodynamics. This idea must include new physical laws, independent of the established set, and would give a significant role to macroscopic information.

Communications engineering has a sophisticated information theory of its own, which includes the idea of information entropy, a measure of how deterministic a system is. Might incorporating this concept into classical thermodynamics prove sufficient to explain causal emergence? Might it offer up the missing physical principle, or will we need to create a new theory as a fourth, independent pillar of physics? Wherever this leads, information will take centre stage.

More enduring outfits bring many benefits

4 June, p 38

From Geoff Harding, Sydney, Australia

The best solution to the huge environmental problem posed by fast fashion is to encourage the manufacture and purchase of considerably fewer, but higher quality, garments – particularly those that could be classified as "eternally fashionable".

Manufacturers would probably lose out a little, due to producing clothes more slowly and carefully, and using better quality materials. But these garments could then be sold at higher prices. Also, a "green production" label would be a hit with customers, especially in high-income countries.

More garments like jackets could be made reversible, thus offering two designs to increase appeal. Higher-quality clothes are almost certain to be worn for longer and, ultimately, to be more suited for resale at charity and second-hand outlets. Here in Australia, such stores have to discard many donations of poor-quality items due to deterioration.

Nuclear power? Better the devil we know

28 May, p 38

From Graham Reynolds, Coventry, West Midlands, UK

In a low-carbon future, the need for nuclear power is probably inevitable. For those who worry about radiation from nuclear waste, consider this: what would be better, to have this waste stored somewhere known and safe for thousands of years, or to suffer an indeterminate period, perhaps millions of years, of worldwide, incomprehensible damage to the climate – assuming we cannot control our emissions and climate change worsens?

How to explain the physics of flying upside down

11 June, p 28

From Tony Rimmer, Lytham St Annes, Lancashire, UK

I understand Chanda Prescod-Weinstein's problem with the physics of flight. As a designer and builder of model aircraft when young, I found references to Bernoulli's principle were quite unhelpful to explain lift, especially when considering a wing with an identical top and bottom.

The missing element in most of the Bernoulli expositions was something called angle of attack, which refers to the orientation of the wing in the pitch axis, relative to direction of travel. If the leading edge of the wing is higher than the trailing edge, it creates lift.

The mystery of inverted flight is resolved by knowing that pilots can pitch up the nose of their aircraft, which restores the angle of attack relative to the flight path while inverted. This mode of flight increases drag, so is merely inefficient, not mysterious.

Flying foxes may be democratic too

28 May, p 23

From Talia Morris, Cape Tribulation, Queensland, Australia

You report that "Jackdaws 'vote' on mass exodus" before taking flight together. At Cape Tribulation Tropical Research Station, my colleagues and I believe we have seen similar vocal behaviour in spectacled flying foxes (*Pteropus conspicillatus*). For several hours before a colony-wide relocation, there is a massive increase in squawks, screeches, chattering and general "conversation". Could this behaviour be common across different flying species?

High time we dusted off The Limits to Growth

Letters, 4 June

From Paul Daws, Poringland, Norfolk, UK

To add to the letter on degrowth, 50 years ago, a report called *The Limits to Growth* was published. This was based on work at MIT, yet was ridiculed by economists, politicians and bankers. It was years ahead of its time. Every word of it is now coming true and it should be dusted off and made top of the agenda at the COP27 climate summit. If world leaders aren't prepared to stand up and say that there are limits to growth, there is no point in having a COP28.

Nectar-guzzling urban bees remind me of something

21 May, p 28

From John Fewster, London, UK

Graham Lawton writes about the plight of the bumblebee versus the honeybees kept by urban hobbyists. The analogue to humans seems obvious: overly dense communities of urbanites muscling in and mindlessly using resources, while pastoral folk and the wider environment suffer most of the consequences.

Given recent history, even 2°C seems beyond us

Leader, 11 June

From Perry Bebbington, Kimberley, Nottinghamshire, UK

In 2020, the world almost totally shut down due to covid-19, but we only saw a drop in carbon dioxide emissions of around 6 per cent. Given this, there seems no chance of getting the yearly cuts needed to limit temperature rise to 2°C. Global warming is happening and happening big. Claiming anything else is holding out false hope.

Bikers can see clearly now the insects are gone

14 May, p 23

From Peter Hawes, Bournemouth, Dorset, UK

You recently reported on insect decline as measured by bug splats on cars. I have ridden motorcycles for 61 years. During that period, bug splats on screens and helmet visors have declined considerably. I always had to carry visor cleaning equipment, with which I regularly removed the remains of a serious number of bugs, but no longer. ▮

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters

Letters sent to New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT will be delayed

For the record

▮ **Our look at the condition known as brain fog that can result from covid-19 featured Courtney Shukis (11 June, p 38).**

New Scientist

Diversity Internship

Learn to be a science journalist

New Scientist is the world's most popular weekly science and technology magazine. Founded in 1956 for "all those interested in scientific discovery and its social consequences", the publication's journalists cover international news from a scientific standpoint and ask the biggest-picture questions about life, the universe and what it means to be human.

These fundamental mysteries are of interest to everyone, whatever their background. But both science and journalism suffer from a lack of diversity, with many talented individuals and valuable perspectives excluded or lost from these fields.

To address this, *New Scientist* is offering a learning and development opportunity open to anyone from an ethnic minority background.

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The only entry requirements are that you will have completed a science, technology, engineering, mathematics or computing degree by the start of the internship, and that you have a demonstrable interest in writing, video editing or journalism.

How to apply

We ask applicants to submit 200 words explaining how they meet our requirements (see left) and why they are the right person for this internship. We also ask candidates to write an article, between 500 and 800 words long, on a recent scientific discovery, or create a 2 to 3-minute video on a scientific topic that interests them.

The closing date for applications is 8 July.

To apply, please visit tinyurl.com/nsinternship2022

The internship is a positive action scheme, under the Equality Act 2010.

M-IMAGEPHOTOGRAPHY/ISTOCK

Passing the smell test

When Paola Totaro lost her ability to smell, she set out to investigate the least studied of our senses in this timely book, finds **Vijaysree Venkatraman**

Book

On the Scent

Paola Totaro and Robert Wainwright

Elliott & Thompson

EARLY in the covid-19 pandemic, London-based reporter Paola Totaro lost her sense of smell. Feeling trapped in a sensory void, she began investigating the mysteries of smell, and the result is the engaging and timely *On the Scent*, written with her husband, journalist Robert Wainwright.

The pandemic has put a spotlight on olfactory impairment. The coronavirus has affected millions of people's ability to smell, and the symptom has persisted in some, months after the infection has passed. Anosmia is the clinical term for an inability to perceive smell. Parosmia turns pleasant smells into stenches for some (the "fortunate" ones perceive foul smells as pleasant). In phantosmia, people hallucinate smells.

Totaro's personal experience and the authors' sensitive profiles of people with anosmia or parosmia make it clear that a sense of smell can be integral to emotional well-being. Depression, the authors discover, affects a good third of those who have lost their ability to smell. Neuroscientist Oliver Sacks has previously written of "a woman transfixed by grief when she couldn't recognise the smell of her own baby".

Smell is the least studied of our senses. The authors introduce us to the work of pioneering olfactory researchers such as Linda Buck, who identified the family of genes that allow humans to detect and distinguish smells. Buck's fundamental research, for which she won a Nobel prize in 2004, has laid the groundwork for understanding certain diseases characterised by anosmia.

Gathering evidence shows that conditions like Alzheimer's and Parkinson's are associated with an early loss of smell. A dysfunctional sense of smell is also linked with schizophrenia and dystonia. So, in the future, a smell test may be part of routine health check-ups, particularly for older people.

There is no cure for anosmia, but "smell training" can help

VICTOR DYOMIN/GETTY IMAGES

Researchers have found some of the biological mechanisms that lead to covid-19-related smell loss. The virus doesn't infect odour-detecting nerve cells, but attacks cells that play a supporting role in the olfactory system – so regeneration is a possibility.

But no doctor can tell you how long you will be without smell, or even if you will regain it. Though there is no cure for anosmia, a technique known as smell training – regular sniffing of aromas such as rose and lemon – has helped some people with acquired olfactory loss. Patience is key, the authors stress.

On a recent trip to Puglia, Italy, Totaro saw a religious procession where a parishioner was carrying an incense burner. The scent of frankincense and myrrh brought back memories of attending mass with her grandmother – and she wept in gratitude for her newly functioning nose. ▮

Vijaysree Venkatraman is a science journalist based in Boston, Massachusetts

Plastic surgery's first pioneer

Book

The Facemaker

Lindsey Fitzharris

Allen Lane

AROUND 40 million people were wounded or killed in the first world war. "For the first time... Europe's military technology had wildly surpassed its medical capabilities," writes historian Lindsey Fitzharris in her informative book, *The Facemaker*.

Fitzharris introduces us to New Zealand-born ear, nose and throat doctor Harold Gillies. By 1917, he had become the world's pre-eminent specialist in plastic surgery, developing techniques still used today like the "bishop's mitre flap" for the nose, or the "tubed pedicle" for severe burns.

Plastic surgery in the 19th century was crude, with masks generally used to cover scarring. Gillies travelled to various countries to shadow doctors and dentists whose methods had reached him. After war broke out, soldiers with severe facial injuries streamed to him at his institution, The Queen's Hospital in Sidcup, UK.

One patient, Sidney Beldam, was struck by a piece of shrapnel, slicing through the right side of his face and tearing off a large portion of his nose. Gillies reopened the hastily sewn-up wound and sutured a flap of healthy tissue to "fill out the cheek". Beldam would then undergo 39 more operations to repair his nose from scratch.

Fitzharris portrays Gillies as forward-thinking for recognising that this burgeoning medical field required a multidisciplinary approach and hiring doctors, dentists, sculptors and artists in his pursuit. She paints a powerful portrait of a gifted man. ▮

Oliver-James Campbell is a freelance writer based in York, UK

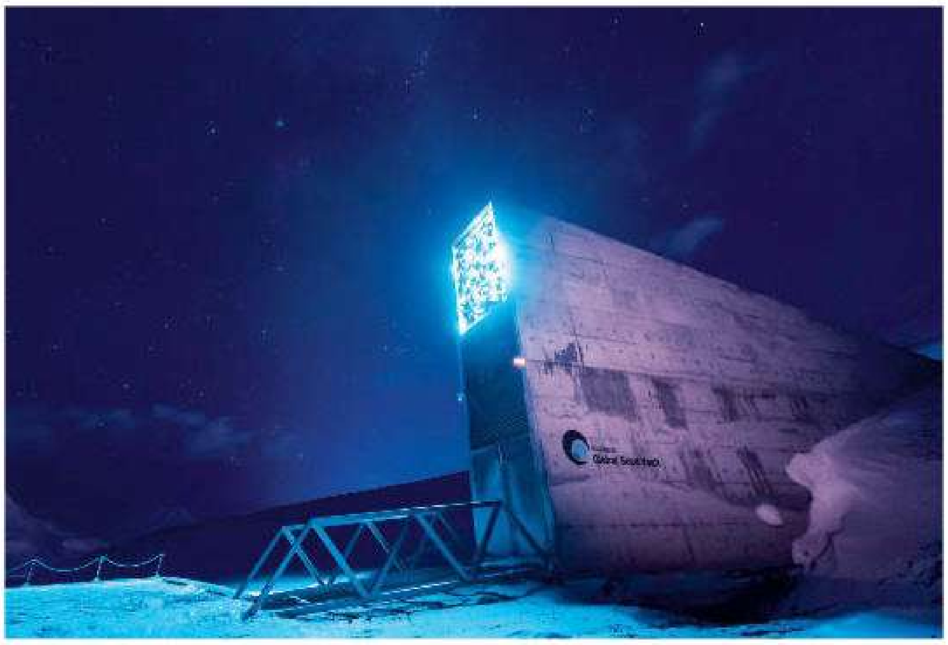
Cool tunes

From work by an Indigenous orchestra to the songs of a sci-art pioneer, music is being preserved in ice, finds **Chelsea Whyte**

Music

Global Music Vault

Spitsbergen,
Svalbard archipelago, Norway



COURTESY OF GLOBAL MUSIC VAULT

Disaster recovery: a global music repository joins the global seed bank to preserve Earth's heritage

TOWERING over the frozen island of Spitsbergen, the largest in the archipelago of Svalbard, Norway, is a "doomsday vault". Over 1 million seed varieties from around the world are being held in this mountainside facility, which is designed to preserve agricultural biodiversity and shield global food supplies from disaster. Now, a new kind of deposit is on its way to the mountain – the Global Music Vault (GMV), will store music from traditions across the planet.

"We see on a global scale that music is sometimes fragile, music gets lost," says Alfons Karabuda, president of UNESCO's International Music Council and a board member for the GMV. A recent example he cites is Afghanistan's musical culture, now under threat because the Taliban has banned music and instruments are being smashed and burned across the country.

The first deposits to the GMV include: a number of contributions from the International Library of African Music in South Africa, which has one of the world's biggest African music repositories; a selection of New Zealand music, provided by the Alexander Turnbull Library in Wellington; material from the Orchestra of Indigenous Instruments and New Technologies in Argentina, which uses Central and South American instruments; some a cappella music by the Fayha Choir in Lebanon; and pieces from Ketebul Music in Kenya, a non-profit arts organisation that preserves the musical traditions of East Africa.

"We could have gone for the Billboard Hot 100 or the most popular playlists on streaming services," says Karabuda. "Instead, we have people representing music [from] all over the world helping us. And we are also looking at indie musicians, like Beatie Wolfe."

Wolfe says that the project fits with her desire to push boundaries, which she does by creating new formats for her music and making science accessible through her art. In 2017, she debuted her album *Raw Space* in an augmented reality livestream from what was then the quietest room on Earth, Nokia Bell Labs's anechoic chamber in Murray Hill, New Jersey. A recording of this stream was beamed to the stars via the Holmdel Horn Antenna, which once detected the cosmic microwave background and provided evidence in support of the big bang theory.

"Music has to be included in this vault because it is one of the things that keeps us alive inside"

In 2020, Wolfe built a digital installation, featuring her song *From Green to Red*, which uses NASA data to illustrate changes in atmospheric carbon dioxide over the past 800,000 years. "It is an environmental protest piece," she says, explaining that humans have damaged the planet more in the past 25 years than in all our prior history. "Even in our knowing [about climate change], we have increased emissions so significantly," she says.

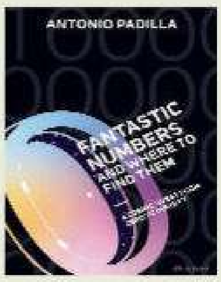
Wolfe has chosen this song to go in the vault, along with *Oh My Heart*, which debuted at the 2021 Nobel Prize Summit. To protect them, the GMV has teamed up with a Microsoft research group working to develop sustainable, long-term data storage. Lasers will etch the song data onto silica glass plates around the size of drinks coasters. This inert material can withstand harsh environments, resist electromagnetic pulses and could last at least 1000 years.

"The idea of unearthing it in thousands of years is almost too exciting a prospect, just because I feel we may be short-lived as a species," says Wolfe. But she isn't a total pessimist: depositing music in the vault suggests at least some hope for a future audience. As she says, nature and art aren't just for surviving, but for thriving: "I feel like music has to be included in this vault because it is one of the things that keeps us all alive inside." ▮

Don't miss

Visit

Back to Earth at the Serpentine Galleries, London, brings together artists, scientists, poets, film-makers and more. This new exhibition is a response to the climate crisis, accompanied by a series of live events. Closes 18 September.



Read

Fantastic Numbers and Where to Find Them is an irreverent tour of extraordinary numbers in physics, big, small and bafflingly infinite. Be amazed as physicist and YouTuber Tony Padilla reveals the inner workings of reality. Available from 30 June.

Watch

The Mind of a Bee will be explored by Lars Chittka, author of a book on the subject, in a talk for the Linnean Society of London. Bees count, use tools, solve problems and learn by observing others. Watch online at 6pm BST on 29 June.

BOTTOM: ANTONIO CARLOS VOLANTE/500PX/GETTY; TOP:COURTESY E-WERK LUCKENWALDE AND KARRABING FILM COLLECTIVE/STEFAN KORTE IMAGES

The games column

Send in the backup

From global chip shortages to the war in Ukraine, major games studios are being forced to delay their big releases. Luckily, eager players can find solace in smaller games like *Silt* or *Spacelines from the Far Out*, says **Jacob Aron**

Jacob Aron is *New Scientist*'s news editor. Follow him on Twitter @jjaron

Games

Silt

Spiral Circus

PC, PlayStation 4/5, Xbox Series X/S, Nintendo Switch

Spacelines from the Far Out

Coffeenauts

PC, Xbox Series X/S

Jacob also recommends...

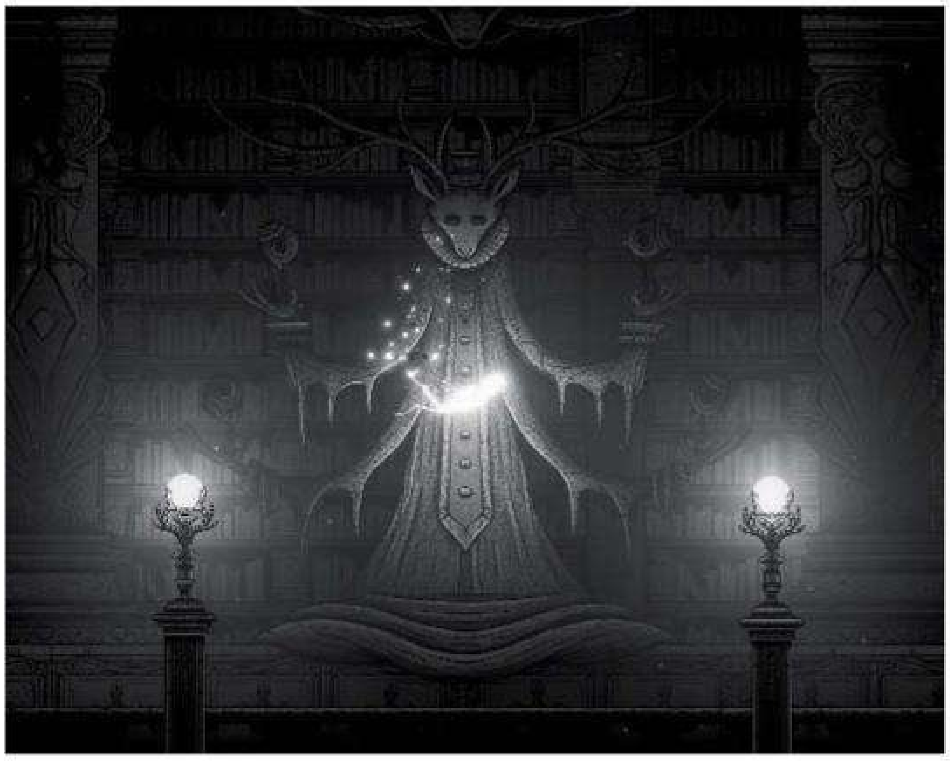
Game

Final Fantasy VII Remake

Square Enix

PC, PlayStation 4 and 5

I played about half of this reimagining of the classic RPG at the start of the year, but got distracted by other things. Now we are in the quiet summer months, I am back in the world of Midgar and absolutely loving it.



SPIRAL CIRCUS

Dive into the beautiful, if creepy, underwater world of *Silt*

AS I have written here before, the covid-19 pandemic and global chip shortage have caused havoc for the video game industry.

Whether due to the difficulty of collaborating from home, or an inability to produce consoles for eager players, major titles face repeated delays. Even the Russian invasion of Ukraine has contributed, forcing Ukrainian developer GSC Game World to indefinitely postpone its survival horror entry, *Stalker 2: Heart of Chernobyl*, which I named as one to watch at the start of the year.

So, with big releases in short supply, I have been checking out some smaller morsels. First up is *Silt*, an atmospheric, underwater puzzle game. You play as a diver and navigate a black-and-white world depicted with hand-drawn artwork. It is gorgeous, creepy and features far too many things with teeth for my liking.

The twist is that the diver can possess denizens of the deep: you use an ethereal light that reaches out from your body to take control of them. These beings help you to puzzle-solve. One little nipper can cut through wires that block your path, and another creature, which looks like a hammerhead shark, is able to bash through rocks. You even get to chain these skills together, "soul-hopping" between animals in an attempt to progress.

Soon, you find yourself going up against large boss enemies that take multiple stages to conquer. The first of these is an anglerfish, whose luminescent lure you must chase through a series of tunnels before you face the beast itself. Once you have defeated this boss, you absorb its soul and things get a bit weird, in a Lovecraftian way.

> **"I failed to notice that we were off course because I was too busy dancing to amuse the passengers"**

Sadly, I didn't find that *Silt* had a lot of staying power overall, with the impressive atmosphere and visuals failing to compensate for the fairly linear puzzles and occasionally fiddly controls.

My second choice is *Spacelines from the Far Out*, a quirky game about running a space travel business. This sports a liberal dash of kitsch that doesn't feel a million miles away from 1960s animated sitcom *The Jetsons*.

The game puts you in charge of a "spaceliner", which you use to ferry passengers between planets, space stations and more. You, and up to three of your friends, then have to juggle between the roles of pilot, navigator, flight attendant, mechanic and even janitor, as you attend to your passengers' needs while simultaneously attempting to avoid deadly asteroids.

The routes you travel are broken up into short hops. These last only a minute or two, and you often get to choose which one to attempt. Reaching your destination might give you access to a shop where you can improve your ship, or refuel and repair it. If you fail to complete a journey, however, it is game over – and unless your ship was insured, you must restart your burgeoning business from scratch.

This set-up makes for lots of slapstick comedy, like when you serve reheated space food while making sure the gravity generator works. Your first ship doesn't even have the power to keep everything switched on, so I needed to switch off the navigation system in order to power up the communications array and contact new passengers.

One of my runs ended with the ship endlessly drifting through space after I ran out of fuel. I had failed to notice that we were off course, since, unable to afford a TV, I was too busy dancing to amuse the passengers. Let's hope that real "spaceliners", such as Jeff Bezos's Blue Origin, are prepared to splash out on in-flight entertainment. ▮

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Time to get personal

Custom-made vaccines for individual cancer patients fire up their immune systems to precisely annihilate their tumours, heralding a long-awaited revolution in treatment, reports **Alice Klein**

WHEN Mark Lashway found out that his melanoma skin cancer had spread to his lungs, he immediately quit his job as a chemistry teacher in Hillsdale, New York, and prepared for the worst. "I knew the survival rate was only 15 per cent and I was frightened. It was the realisation of like, 'Holy cow, is this it?'," he says.

Seven years later, the 67-year-old is now seemingly cancer-free after becoming one of the first people in the world to receive a personalised cancer vaccine – one that was designed just for him so that his immune system could attack and destroy the unique biology of his tumours. "I had these three lung tumours that were so big I could see them and feel them – one was protruding out of my back," he says. "Then a few months later [after treatment], I'm waiting for my results and my oncologist comes in and says, 'I've got the best news a doctor can tell you – you've had a 100 per cent response.' The tumours were all gone."

Lashway is now one of a few hundred cancer patients who have received personalised vaccines as part of several clinical trials. Other participants have also had remarkable responses, even some with cancers that would be hard to treat conventionally. "I would say these vaccines are the next big thing," says Adilia Hormigo at Mount Sinai Hospital in New York, who has used them to treat some people with a notoriously deadly brain cancer known as glioblastoma.

We have long known that the immune system naturally tries to fight cancer, but it is often outsmarted by cancer's tricks. Many decades of research have tried to dial up this natural response. The first big breakthrough came in 2011 with the approval of "checkpoint inhibitors" – a class of drugs that boosts the anti-tumour activity of important parts of the immune system called T-cells. Thanks to checkpoint inhibitors, some people with cancer who would have been given months to live have survived more than a decade.

Checkpoint inhibitors, however, don't work for everyone's cancer: 50 per cent at best survive for five years in melanoma clinical trials. They also don't work for every type of cancer – for example, they are powerless against most bowel cancers.

That is why researchers have continued to search for other ways to supercharge the immune system against cancer (see "Immune boost", page 40). One strategy is vaccination, which aims to increase the number of T-cells that can fight tumours. If T-cells are thought of as an army, checkpoint inhibitors make the soldiers stronger and vaccination recruits extra soldiers. A combination of these strategies could be extremely powerful.

We normally think of vaccines as being used to prevent disease – like vaccines that protect against covid-19 – but they can treat disease too. The idea of a vaccine is to help the immune system battle something harmful, be it a virus or a cancer cell. Our immune systems do this by pumping out substances that recognise a target part of a disease-causing entity, such as the proteins on the outside of a virus.

Unfortunately, cancer vaccines have previously failed to live up to their promise. One of the biggest challenges has been finding the right targets for these vaccines, as every individual's cancer is genetically different. This means that a vaccine that works for one person is unlikely to work for another.

About 12 years ago, Eric Lander, one of the leaders of the human genome project and founding director of the Broad Institute in Cambridge, Massachusetts, wondered if a personalised approach would work best. With the cost of genetic sequencing falling, he thought it might be possible to analyse the DNA of a person's tumours and design a vaccine to target their unique mutations.

Lander approached oncologists at Dana-Farber Cancer Institute in Boston to see if they would be interested in giving this a go. They agreed and applied for approval from the US Food and Drug Administration (FDA). "It was kind of a big deal, because no one had done this before – the idea that every single participant would get a different vaccine was something the FDA wasn't used to," says Patrick Ott at Dana-Farber. "We had to convince them that we didn't need to do animal studies beforehand because it wouldn't make sense." ›

SHUTTERSTOCK / MOLIBDENIS

After getting the FDA on board, Ott and his colleagues enrolled eight people with advanced melanoma, including Lashway, between 2014 and 2015, to test personalised cancer vaccines. They chose melanoma because it is an example of a "hot tumour", one that is easily recognised by the immune system because of its many mutations.

First, they took samples of tumour cells and normal cells from each patient and genetically sequenced them. Next, they used powerful computers at the Broad Institute to compare the two so they could identify mutations in the tumour DNA. Some of these mutations caused abnormal proteins to be expressed on the tumours, making them look different to normal cells.

For each patient, the team then manufactured a vaccine that contained snippets of up to 20 of these abnormal proteins. The idea was to expose the immune system to these snippets so that many more T-cells could learn to recognise them. When this new army of T-cells then encountered the same abnormal proteins on tumour cells, they would know to attack them.

Lashway received seven shots of his bespoke vaccine over the course of six months. He experienced no side effects aside from some itchy blisters that broke out on his skin. "The fact that these vaccines are so tailored to each patient's tumour makes them really safe," says Ott. This is because the vaccines prompt the immune system to attack tumour cells while leaving other cells in the body alone.

At the end of the six months, Lashway began getting injections of a checkpoint inhibitor called pembrolizumab – more commonly known as Keytruda – to give an extra boost to the newly recruited T-cells. "It was like a one-two punch," says Lashway. That was when his tumours started rapidly shrinking before his eyes. "I could actually see the one that was sticking out of my back getting smaller."

It is hard to know how much of Lashway's impressive recovery was due to the personalised vaccine and how much to the pembrolizumab. Ott believes the synergy between the two was key. "It is possible that the pembrolizumab did it alone, but it would be unusual to have such a profound response as quickly as he had it," he says.

Of the seven other trial participants, most of whom received the vaccine without any pembrolizumab, six are still alive and appear to be cancer-free. "We showed that the personalised vaccines were safe and, excitingly, produced a very robust immune response, which was something that hadn't been shown before with cancer vaccines," says Ott.

Hormigo and her colleagues at Mount Sinai Hospital have since used a similar approach to make personalised cancer vaccines for people with glioblastoma. In a trial involving 12 people with the disease, they found that personalised vaccines, combined with another experimental treatment, induced strong immune responses. The average survival for people with glioblastoma is normally just 15 months, but nine of the trial participants are still alive more than two years after treatment and all but one appear to be cancer-free. "I'm very pleased with the results we have so far because glioblastoma is such a difficult disease to treat," says Hormigo.

Both Ott and Hormigo, however, caution that their trials were small and unable to show conclusively that personalised cancer vaccines are effective. "Ultimately, we need large randomised controlled trials to show that this can actually work, but you can imagine that it's not cheap. Each vaccine can cost $100,000 or more," says Ott.

IMMUNE BOOST

There are three main ways to make the immune system better at fighting cancer, and they all boost the activity of immune system components called T-cells

CHECKPOINT INHIBITORS

These drugs block a mechanism that cancer cells often use to avoid being attacked by T-cells.

CAR T-CELL THERAPY

This involves removing T-cells from someone's blood, engineering them in a lab to give them receptors that make them better at recognising cancer cells, and then injecting them back into the patient. It is mostly used to treat blood cancers such as leukaemia.

PERSONALISED VACCINES

These are designed on a patient-by-patient basis and train an individual's T-cells to recognise the unique set of proteins on their tumours so they can then attack them.

Fortunately, there are some companies that can afford this kind of research. These include BioNTech in Germany and Moderna in the US, which both began working on personalised cancer vaccines many years ago, but shot to fame for their covid-19 jabs.

Inside job

The two companies have taken a slightly different approach to Ott and Hormigo. Instead of making the vaccines out of protein snippets, they make them out of messenger RNA – or mRNA – that instructs cells to make the relevant protein snippets inside the body.

The BioNTech version trains each cancer patient's immune system to recognise up to 20 unique markers on their tumours. Moderna's does the same, but targets up to 34 unique markers. Both prompt the immune system to selectively kill tumour cells.

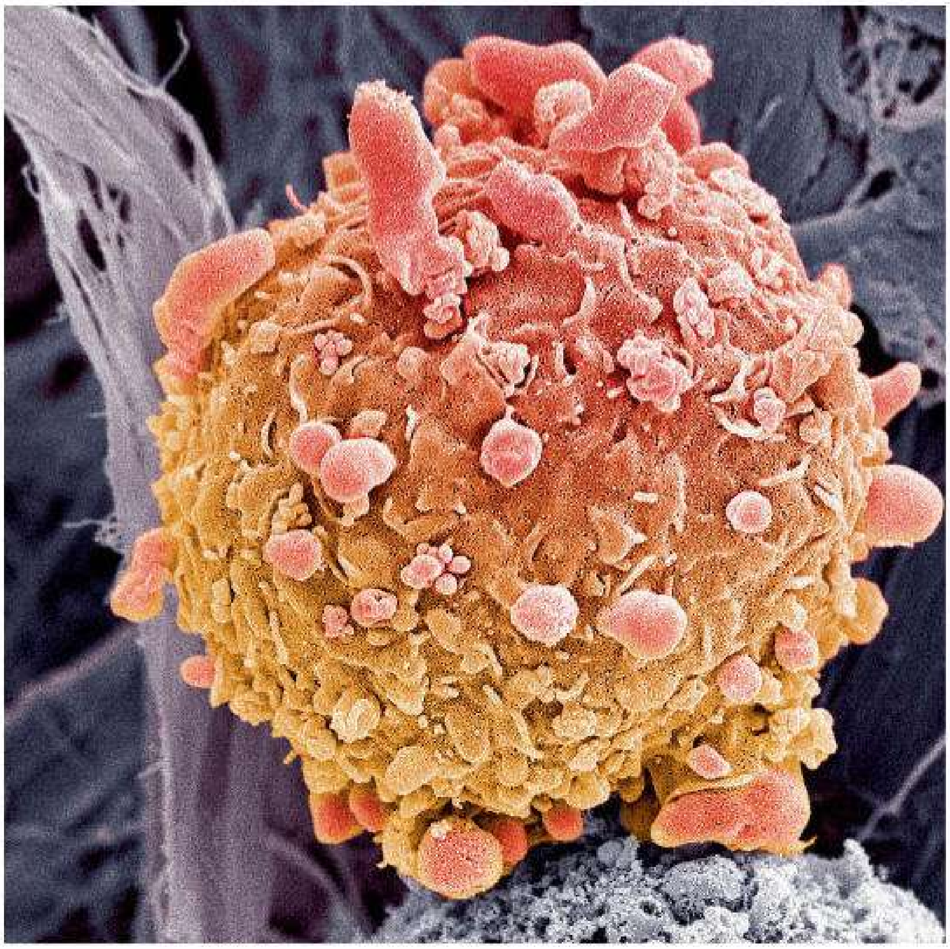
"The beauty is, we start with the patient. We learn from the patient. And we design a complete drug that is personalised in every way," says Praveen Aanur, one of Moderna's chief oncologists.

BioNTech and Moderna have both reported encouraging early results for their personalised cancer vaccines in small trials. For example, in a study of 10 people with metastatic head and neck cancer, Moderna's personalised vaccines stopped the cancers from progressing for an average of 10 months when combined with a checkpoint inhibitor. This figure would normally be closer to two months with a checkpoint inhibitor alone.

And 8 of 16 people with pancreatic cancer who received BioNTech's personalised vaccines and a checkpoint inhibitor shortly after their tumours were surgically removed were still cancer-free 18 months later.

Now, BioNTech and Moderna are both conducting larger randomised controlled trials in people with melanoma, enrolling more than 130 participants each. In both trials, melanoma patients have been randomly assigned to receive a personalised cancer vaccine and the checkpoint inhibitor pembrolizumab, or pembrolizumab alone. This should finally confirm whether personalised cancer vaccines do provide additional benefits on top of checkpoint inhibitors. The first results are expected towards the end of this year.

Not everyone is convinced that personalised



Melanoma cancer cells, as pictured here, can be wiped out by the new vaccines

STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

> **“These vaccines are targeted, so they don’t make people sick – unlike chemotherapy”**

cancer vaccines will live up to their promise, says Riccardo Dolcetti at the Peter MacCallum Cancer Centre in Melbourne, Australia. “Many clinicians have memories of the failed cancer vaccines of the past, before they were personalised,” he says. “It can also be a challenging concept for regulators because it’s not like a traditional drug, it’s more like a process.”

However, if more positive clinical trial results roll in, “more and more clinicians should become convinced that this is the right thing to do”, says Dolcetti. One of the best things about vaccines is that their targeted nature means that, unlike chemotherapy, they don’t make patients sick, he says.

The two major drawbacks of personalised vaccines are the time it takes to make them and their enormous cost, says Dolcetti. Companies like Moderna and BioNTech can do everything in-house and make the process more streamlined. But it still takes between four and six weeks for them to make each vaccine. Aanur won’t reveal the cost, but he says that over time the process should become cheaper and faster.

A high level of quality control is also required so that patients’ vaccines don’t get mixed up, because they are all different, says Aanur. At Moderna, a digital barcoding system follows each vaccine’s production from start to finish and is checked every step of the way to make sure the right treatment ends up in the right patient, he says.

Although personalised cancer vaccines have shown promise in hot tumours, we still don’t know if they could be used against “cold tumours” – those that aren’t easily recognised by the immune system, including many forms of bowel, breast and prostate cancer. In one small trial, Moderna found that its personalised cancer vaccines had no effect in people with bowel cancer. But Aanur says the company is working on ways to switch cold tumours to hot so that they become more susceptible to vaccine treatment. “We want to open all the gates to the T-cells,” he says.

The ultimate goal will be to develop personalised cancer vaccines that stop people from developing cancer in the first place, rather than treating it when it is already established, says Dolcetti. For example, if genetic sequencing could identify an individual’s risk of developing certain cancers, it may be possible to custom-make a vaccine for them that prevents those cancers forming. “The difficulty is knowing what to target, but several groups around the world are working on this,” says Dolcetti.

In fact, it is already possible to prevent some cancers using vaccines. These are cancers that we know are caused by viruses, so we can make vaccines to stop these viruses from infecting us. For example, vaccines against human papillomavirus can prevent cervical cancer and vaccines against hepatitis B virus reduce the risk of liver cancer. Personalised vaccines for preventing non-virus-induced cancers are the next frontier.

For Lashway, getting the opportunity to try a personalised cancer vaccine and having a 100 per cent response has transformed his outlook on life. “I remember after I was diagnosed, I watched a woman on YouTube talking about how cancer can be a gift in disguise and I thought, ‘This is bullshit’, and turned it off,” he says. “But at the end of this, how it’s changed the way I approach life, I think she was right. I feel so lucky.” ▮

Alice Klein is a reporter for *New Scientist* based in Sydney, Australia

Missing the beat

Ecosystems depend on the synchrony of crucial events like the flowering of plants and hatching of chicks. But global warming is causing mismatches that could spell ecological disaster, reports **Graham Lawton**

CARIBOU: JOHNNY JOHNSON/GETTY IMAGES; PIED FLYCATCHER: DAVID KJAER/NATUREPL.COM; SAKURA: SHUTTERSTOCK/AVPROPHOTO

EVERY year in early spring, Japan goes blooming crazy. The first cherry blossoms open in Okinawa in the south in February and the spectacle reaches Tokyo a few weeks later. For the brief period when the trees are in bloom, people gather under the their beautiful pink and white canopies for hanami, the traditional custom of flower viewing. It sounds genteel, but wild parties are known to break out.

Hanami has been taking place since the 8th century, but the historical records tell a curious story. For the best part of 1000 years, hanami in Tokyo and Kyoto reliably occurred in the second week of April. By the 1830s, however, it had begun to shift earlier. Last year, Kyoto recorded its earliest-ever full bloom, on 26 March.

The cause of this moveable feast is climate change. Cherry trees open their flowers in response to a few consecutive days of springtime warmth, which is arriving ever sooner. Early flowering brings the risk of a sudden frost, which can kill off the blooms – and the celebrations.

But what's at play here is much more than an inconvenience for hanami-goers. Similar time shifts are occurring throughout the world with increasingly disruptive effects. "Timing is everything for ecosystem harmony," says Maarten Kappelle at the UN Environment Programme (UNEP) in Nairobi, Kenya. Although these shifts have been apparent for years, Kappelle and others are warning that the disruption now threatens to completely break down ecosystems, leading to catastrophic losses of species and compromised food security. So how badly out of sync is nature – and can we do anything about it?

Natural historians have long been fascinated by the rhythms of life. In the 18th century, Carl Linnaeus, the botanist who devised the way we name and categorise species, kept diaries of when various trees unfurled their leaves, flowered and fruited. In 1853, Belgian botanist Charles Morren coined the term "phenology" for the study of recurring life phases. Around the same time, Henry David Thoreau made six years of detailed phenological records around his home town of Concord, Massachusetts, a labour of love later repeated by botanist Alfred Hosmer from 1888 to 1902.

It was partly these diligent diaries that first alerted modern biologists to the fact that Earth's ecological clock was shifting. In 2003, biologist Richard Primack at Boston University, Massachusetts, working with Abraham Miller-Rushing at the US National Park Service, compared Concord's historical data with their own observations and concluded that plants were flowering seven days earlier on average than they did 150 years ago.

Exactly why wasn't hard to fathom. Meteorological records show that the mean temperature around Concord has risen by 2.4°C since Thoreau's time, largely due to climate change and urbanisation. And, like cherry trees, many plants use rising temperature as a sign that spring has sprung and it is time to bloom.

Migration to moulting

Since Primack and Miller-Rushing's early work, we have collected plenty more examples of shifting phenology, and concern among ecologists has come to a head. In February, UNEP published one of its influential Frontiers reports, which it uses to highlight what it calls "emerging issues of environmental concern". For the first time, phenology is one of the worries the report singles out. It says that 200 species of plant and animal are known to have changed the timing of one or more of their life stages, on average bringing them forward by 2.8 days per decade. The list of species affected includes birds, mammals, insects, fish, crustaceans, molluscs, plants and plankton; the phenological events cover everything from breeding to pollination, migration, moulting and hibernation.

It isn't just temperature rises that are causing trouble. Changing rainfall patterns are another cause of these shifts, especially in the tropics, where temperatures don't change much throughout the year. Rainfall patterns are also shifting under the influence of climate change. The third important phenological cue, day length, hasn't changed, but this often interacts with the others. For example, temperatures may only trigger an event once day length has crossed a certain threshold.

Phenological events are often synchronised between species. The classic example is a food chain comprised of the pied flycatcher (*Ficedula hypoleuca*), caterpillars and oak

›

trees. Every spring, the birds produce large broods that eat vast quantities of caterpillars – the adults must deliver as many as 60 an hour over the 18 days it takes for the chicks to fledge. But caterpillars are an ephemeral resource, hatching to coincide with the emergence of oak foliage. The birds have thus evolved to breed so that their chicks hatch during maximum caterpillar abundance. The cue they take is temperature, which also precipitates leaf unfurling and caterpillar hatching.

This tightly coupled sequence is being disrupted by climate change. Even though all three events are triggered by rising temperatures, they are responding differently to warming. In some parts of Europe, birds are hatching too late to catch peak caterpillar, reducing the chicks' chances of survival.

It is problems like these, known as phenological mismatches, that are bringing UNEP out in a cold sweat. We have long appreciated that phenological changes can spell trouble for individual species or pairs of species. But there is a dawning realisation that this is a widespread problem that could presage the breakdown of whole food chains or even ecosystems. "This is truly a global problem affecting plant and animal species in mountains, oceans, tropical and temperate forests and polar regions," says Kappelle.

Quite how bad things could get, we aren't sure. "Much of the work so far has been on pairwise interactions like predator-prey or pollinator-plant," says Marcel Visser at the Netherlands Institute of Ecology in Wageningen, who wrote the phenology section of the UNEP Frontiers 2022 report. "There's anecdotal evidence that shifts in phenology weaken relationships in a food-web context, but that is a question that very much needs answering."

Mismatches are especially apparent in the Arctic, where the rate of warming is much faster than the global average. In Greenland, the annual migration of caribou to their summer feeding and calving grounds is triggered by day length, but when they arrive, the burst of nutritious shoots they once relied on has already been and gone because snow is melting earlier. As a result, their breeding success has declined by about 75 per cent.

In the Canadian Arctic, meanwhile, Ross's geese and lesser snow geese hatchlings also miss out on peak vegetation, which has reduced their reproductive success. To add

200

Number of species known to have experienced changes to the timing of key events in their lives

In time for dinner?

In nature, key events in the lives of animals and plants need to synchronise, so that, for example, caribou migrations coincide with the sprouting of new shoots in spring. When events like this don't hit the same beat, it is called a phenological mismatch (see main copy). This may soon pose a danger to humans directly – and the threat is to our dinner plates.

Many staple crops use natural cues such as temperature and day length to decide when to germinate, fruit and set seed, but climate change is making their biological clocks go haywire. Shifts have been observed in cereals, soya beans, cotton and fruit, often affecting quality and yield.

Fruit trees are particularly vulnerable, says Marcel Visser at the Netherlands Institute of Ecology in Wageningen. Flowering is cued by rising temperature, which happens increasingly early, but makes the blossoms vulnerable to sudden frosts. "This year in the Netherlands, it was really warm towards the end of February, all the fruit trees were blossoming and then we got a cold spell and that led to lots of damage." Many fruits also rely on pollinators, which are experiencing their own phenological shifts.

These agricultural changes aren't yet a major threat to food security, says Visser. But according to the UN Environment Programme, they are already complicating efforts to adapt food production to climate change.

Fisheries are also floundering phenologically. Stocks are typically exploited when fish populations are at a seasonal peak, but many are shifting their spawning season, creating phenological mismatches between predator (in this case humans) and prey. Alaska pollock – commonly encountered inside the bun of a McDonald's Filet-O-Fish – are spawning early and missing out on plankton blooms. Off southern California, more than half of commercially important species are spawning too early or late to fully exploit their food supplies. And in 2012, a marine heatwave in the North Atlantic caused lobsters to migrate inshore earlier than normal, leading to a record catch that, paradoxically, almost destroyed the industry as supply vastly outstripped demand and prices collapsed.

Revellers enjoy a hanami festival in Kyoto, Japan

insult to injury, goose eggs have become an important food source for polar bears forced to leave disintegrating seal-hunting ice and repair to land ever earlier.

There are many other examples in the Arctic and, increasingly, elsewhere, and potential for more as the climate hots up. "We certainly see that there is huge capacity for ecological mismatch," says Amanda Gallinat at the University of Wisconsin-Milwaukee. "It absolutely can happen that interacting species shift at different rates or in different directions. So yes, I think it is a danger to biodiversity."

It is often not so much that phenological mismatches alone drive biodiversity loss, she says, rather that they exert extra pressure on an already stressed system. One strand of Gallinat's research concerns North American birds flying south for the winter. In a 2020 study, she found that warming caused the birds to set off later, but made the fruits they rely on along the way ripen earlier, robbing the birds of vital calories – and also depriving the fruit trees of seed dispersal services. Lots of birds die during these migrations at the best of times because it is such a long, demanding journey. The birds are also under pressure from habitat loss, which remains the leading cause of biodiversity loss worldwide. Ecological mismatch could be the final straw.

SEAN PAVONE/ALAMY

Well, in theory. Despite decades of study, our knowledge of mismatches and their impacts is still rudimentary, says Gallinat. "There's enough information for us to know that it is a danger, in part because it has potential impacts that can ripple throughout ecological communities," she says. "But the extent to which those ripples have been demonstrated is still so limited. There's a lot left to learn."

To that end, she and others, including Primack, are developing a new discipline called macrophenology to integrate all of the local and species-level findings into a global understanding of phenological change. The idea is to use new analytical tools and data sources, such as remote sensing and citizen science, to investigate the impact on bigger scales. "There's so much value to local-scale studies," says Gallinat. "But if we aren't able to connect them to one another and identify some patterns or how transferable a single result is from one place to another, then it really limits our ability to predict what might happen next."

Beyond the Arctic

We can make educated guesses about what will happen next. If the fast-warming Arctic is a guide to our future, phenological mismatches are going to become another major driver of nature loss. Aside from reversing climate change, it is difficult to see what to do about it. "It is really tough to know how best to respond to an ecological mismatch once we've identified it," says Gallinat.

It is, however, possible that the Arctic isn't a canary in a coal mine. Ecological mismatches identified thus far tend to involve specialist species heavily reliant on a single food source, and such interactions are unusually common in the Arctic. It may be that the majority of the world's food webs aren't like this and have sufficient redundancy to absorb the blow. "If one resource comes out of sync, a more generalised consumer might shift their diet to consume more of something else," says Gallinat. We may even be able to engineer this by, say, planting later-ripening fruits along bird migration routes.

ROBERT THOMPSON/NATUREPL.COM

Caterpillars are a crucial food for chicks – if they hatch on time

Another defence, says Kappelle, is to give nature a hand by conserving large populations of wild species in order to maintain high levels of genetic diversity. Evolution may then ride to the rescue. Natural selection can sometimes generate new adaptations in the space of a few generations. Great tits have had a similar problem to pied flycatchers in that they hatch too early to catch peak caterpillar. But some populations of great tit in the UK, Czech Republic and Belgium have already reset the timing of their brood to get back in sync with the caterpillar boom, probably through adaptation, says Visser.

But we cannot rely on this. Phenological mechanisms often involve multiple interacting genes and such systems are slow to evolve. On top of that, climate change is outpacing anything that evolution can achieve. It is happening so fast that "many plant and animal species are not able to adapt in a timely manner", says Kappelle. "In the end, we have to recognise that the only way to effectively reduce the negative effect of mismatched shifts of ecological events worldwide is to rapidly reduce carbon emissions and reduce climate change."

On the plus side, says Visser, nature's shifting rhythms are a powerful reminder that we have to get on with that. Having to mow the lawn earlier each year is the kind of change people notice. "Their response is: 'that's not natural'. They feel that things are getting out of balance." Time, indeed, for a change. ▮

Graham Lawton is a staff writer at *New Scientist*

The black hole photographer

Astrophysicist **Feryal Özel** was a pioneer in working out how to capture vivid portraits of distant black holes. Abigail Beall asked her how she did it – and what we can learn from the two photos in the album so far

A FEW weeks ago, we got our first look at a portrait of the mysterious behemoth at the centre of the Milky Way, the supermassive black hole known as Sagittarius A*. The image is an amazing feat of astronomical endeavour, made possible thanks to a planet-sized array of telescopes called the Event Horizon Telescope (EHT). It was even harder to capture than the previous black hole picture taken by the EHT, which was the first ever. But it is also special because this black hole is at the heart of our home galaxy.

Feryal Özel at the University of Arizona was one of the first people to come up with a way of photographing black holes and she is now a key member of the EHT collaboration. *New Scientist* caught up with her to find out what we have learned from the latest image, how it puts our understanding of gravity to the test and what to expect next from the nascent field of black hole photography.

Abigail Beall: What first drew you to black holes?

Feryal Özel: When I started graduate school, astronomy was having a golden age. Part of that was the age of discovery of how black holes and neutron stars behave. Then I realised these are basically extreme laboratories in space. I can combine what I love about theoretical physics with this amazing data and explore things that we can't with a lab on Earth.

What is so mysterious about black holes?

Black holes were, at first, a mathematical construct from Einstein's theory of gravity, general relativity. When gravity is strong enough, the theory allows for a singularity to form, a region with infinite energy density.

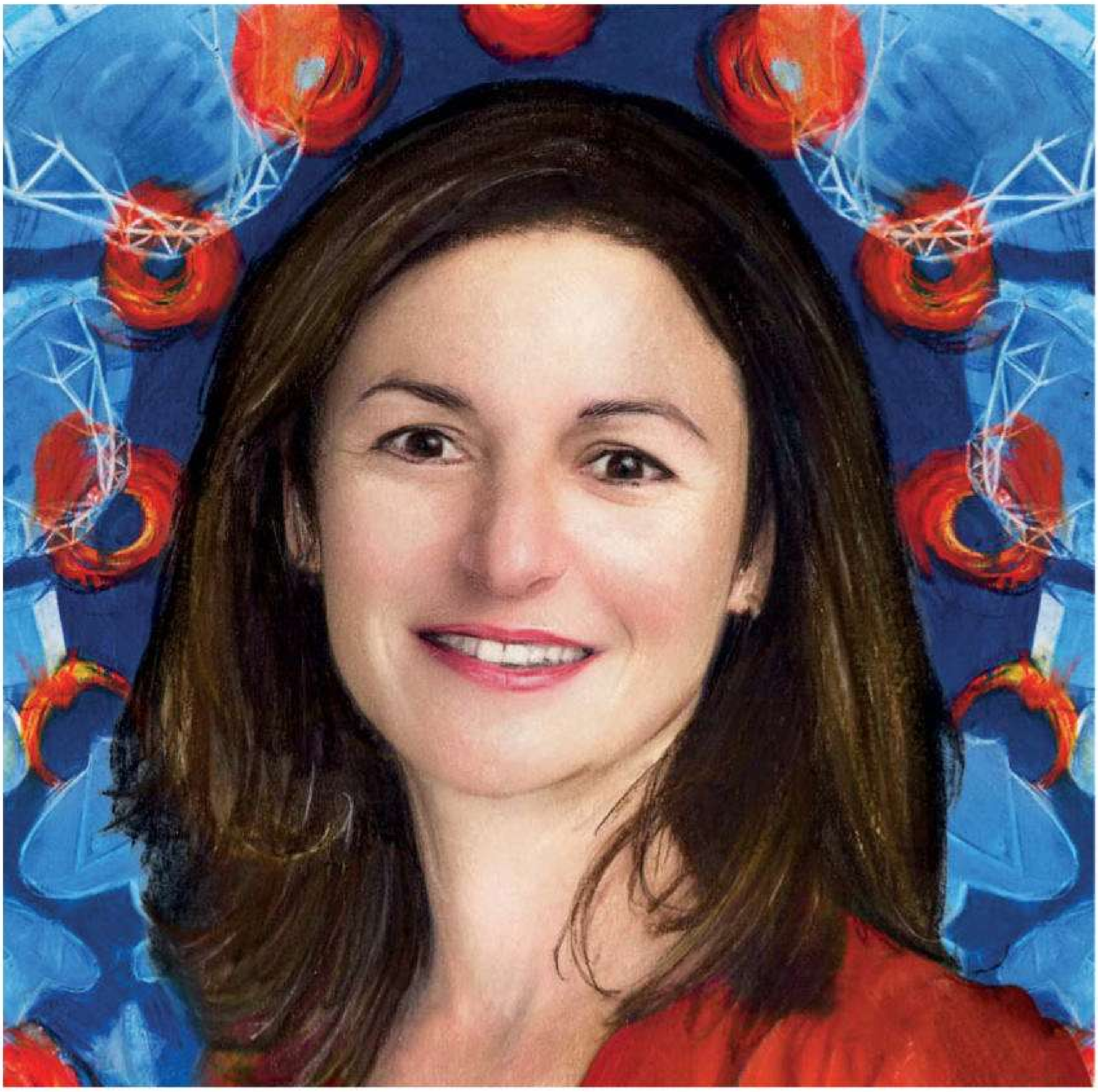
Many people did not believe these would really exist in the physical universe. Then we realised eventually that, yes, when massive stars collapse, they do form something unlike anything else we know of in this universe. There is a region of space that becomes disconnected from our universe called an event horizon. We can no longer receive any information from this region and not even light can escape from it.

One of the things we want to understand is if black holes are exactly what Einstein's theory predicts or if there are some deviations from general relativity that occur when we get close to an event horizon. There is a very basic discrepancy between how general relativity describes the universe and how quantum mechanics, our theory of the subatomic world, describes it. At some point, we would like to reconcile these two theories. And we think that black hole event horizons are places where we could get some clues on how to do this, because you need both theories to work together to describe the extreme physics of black holes.

How did the idea of imaging a black hole first come about?

There were efforts in the 1990s to image black holes. That is when the concept of very-long-baseline interferometry was developed. The idea is to have several telescopes spaced apart from each other and hook them up together to get better resolution (see "How to build an Earth-sized telescope", page 49). Researchers wanted to see how well they could see the black hole at the centre of our galaxy – the trouble was that there is a lot of gas and dust around the black hole that gets in the way.

In the late 1990s and early 2000s, we developed much better models of the environment around black holes. I had the idea of asking: are there any wavelengths of light that we could observe so that we could see the black hole without our view being impeded by the torus of gas and dust surrounding it? What will it take to get down to the event horizon? ›



NABIL NEZZAR

And what does it take?
I realised that the types of black holes we have in our vicinity have a peculiar property: they belong to a class of low-luminosity black holes that make their imaging possible with radio telescopes. I started doing simulations to determine the wavelength at which we would be able to see all the way down to the horizon of these black holes. That helped set the initial observations of black holes at 1.3 millimetres, which is the current observing wavelength of the Event Horizon Telescope. Then it just went from there.

> "Black holes are unlike anything else we know of in this universe"

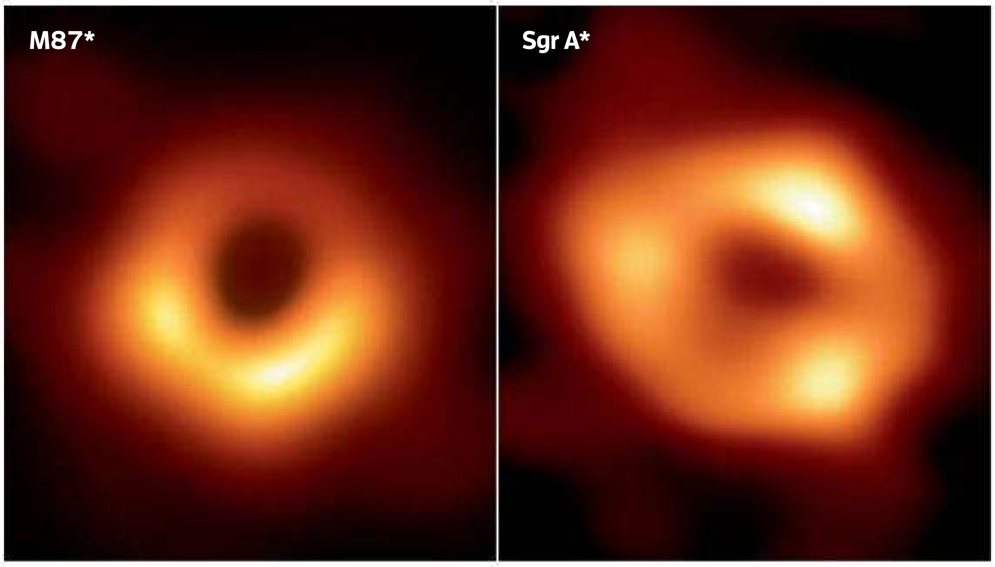
CLEM & ADRI BACRI-NORMIER (WINGSFORSCIENCE.COM)/ESO

Above: The ALMA observatory in Chile, part of a global network of telescopes that captured the images

The first image of a black hole was of M87*, the one at the centre of galaxy M87, in 2019. What was it like seeing that for the first time?
It was really amazing. EHT collects data through interferometry: it is pairs of telescopes getting little bits of information, and then we synthesise it into a single image. But even the interferometric data had a telltale shape that was like: "Oh my God, this looks like a ring!" That was the moment we realised it had worked.

And we have just had the second image of a black hole, this time Sagittarius A*, the one at the centre of our own galaxy. It was a little different than the image of the black hole in M87. We collected the observations for this work in 2017 and we knew early on that there was again a ring-like structure, we could tell its size pretty much from the get-go. But we were worried because the gases move much more quickly around this black hole than they do around M87*, largely because it is smaller, and that could blur or produce misleading artefacts in the image. We also had to deal with the blurring that comes from the light travelling through the disc of our own galaxy, which we call interstellar scattering. It took at least a couple of extra years before we could say, "OK, we are sure that we are not baking any artefacts into the results that we will share with the scientific community and the public".

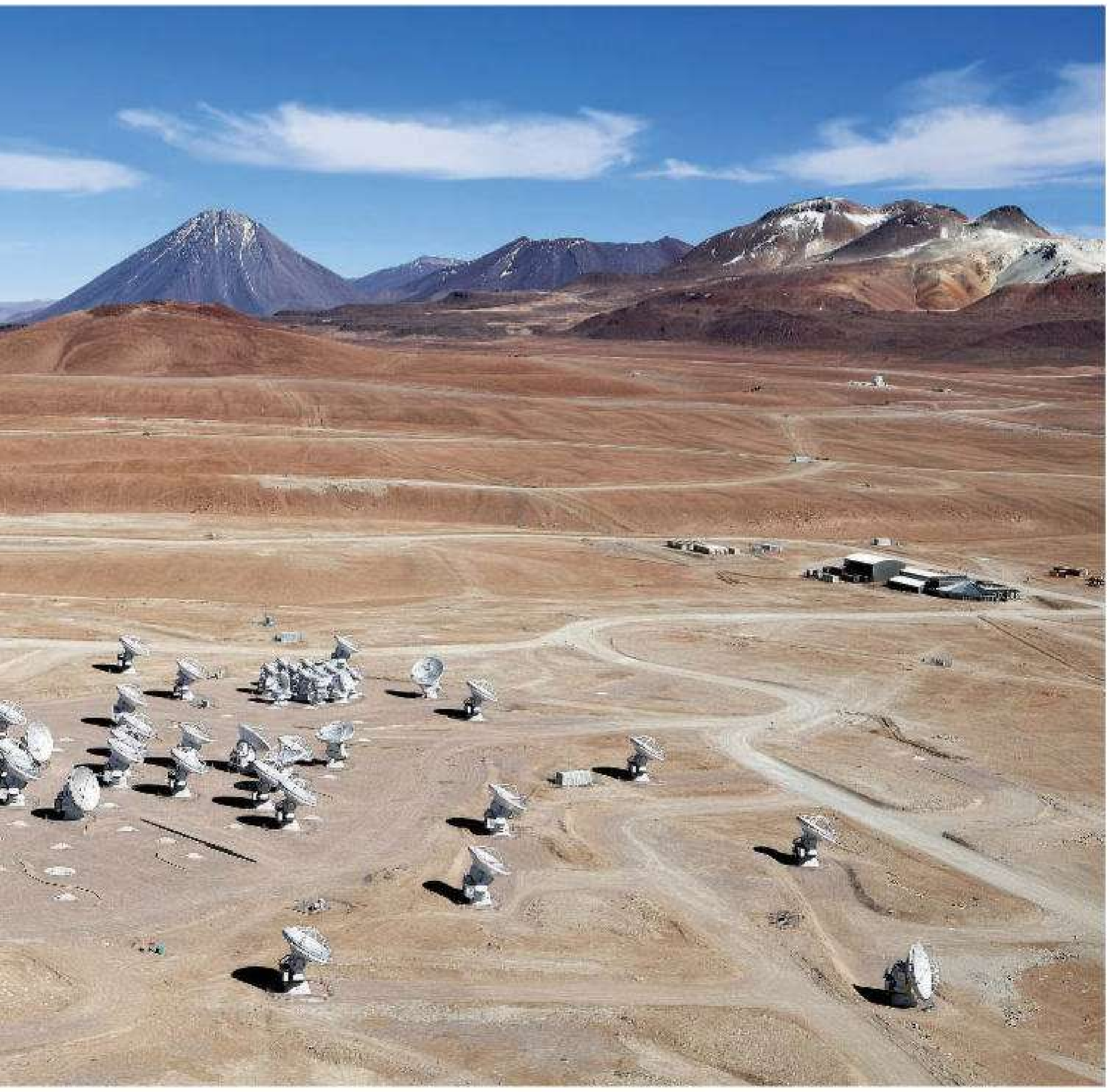
How is M87* different to Sagittarius A*?
They're both what we call "radiatively inefficient" black holes, meaning that, as matter falls into them, we don't get a tonne of light out, because matter can't radiate very efficiently when its density is low. But beyond that, they're very different. The M87 black hole is more massive by a factor of about 1500. Sagittarius A* is in the millions of solar masses, M87* is in the billions of solar masses. They're very different in their environment and what we know about them through our other observations. M87* launches a jet of high-speed particles that is almost the size of the parent galaxy, which is how we suspected there was something at the centre in the first place. We have not been able to see a jet feature in Sagittarius A*, even a small, weak one, in any wavelength that we have studied.



EHT COLLABORATION

Left: The first two black hole photos

Although the black holes are quite different, the two portraits of them look very similar. Is this what you expected?
People might assume that it was disappointing to see another doughnut, but it was actually a very joyful and reaffirming feeling. With Sagittarius A*, I was simultaneously delighted to have a picture of our own black hole and to confirm that the features we saw were a result of the universal laws of gravity rather than some



How to build an Earth-sized telescope

To snap a picture of a black hole, you need a telescope with an incredibly high resolution. The way you normally get higher resolution is by building larger telescopes – but there is a physical limit to the size one telescope can be. The Event Horizon Telescope collaboration got around this by using a technique called very-long-baseline interferometry. It uses radio telescopes thousands of kilometres apart, which each observe the same part of the sky at the same time, and then they combine that data into one image. This creates an Earth-sized interferometer, which gives the same kind of resolution as one telescope with a dish thousands of kilometres wide.

consequence of the particular environment of one black hole.

It could be that if you put two similar black holes in different environments, they end up looking very different. There are all sorts of ways these things could look: they could be brighter or dimmer, or look like a quasar, with two jets coming from their middles. If this were the case, it would tell us that the environment mattered more than just the extreme gravity. But what we are seeing is that, in both M87* and Sagittarius A*, the innate properties of the black hole dominate and control what the object looks like.

How can these images help us test general relativity?
We can look for tests of relativity in the black holes' immediate vicinity. Can we see any hint that something is different from what is predicted? Maybe the shape or size is different than what we expected. There are also theories that say the event horizon might change as a function of time. By looking at images of the black holes at different points in time, we want to understand if we can get hints of deviations from relativity that way.

With the Sagittarius A* image, did you expect there to be something that deviates from general relativity?
Secretly, we were hoping. But right now, it is matching up. Especially in the case of Sagittarius A*, where we knew the mass of that compact object extremely well, by looking at the motions of stars around the centre of the galaxy. We have a very definitive prediction for the size of the shadow – the dark, central part of the black hole – and the ring of bright matter around it. It was a no-wiggle-room test, and it matched up extremely well.

Can we expect pictures of other black holes?
In terms of targets where the EHT could get down to the event horizon scale, Sagittarius A* and M87* are the two main ones. We can study numerous other supermassive black holes in our vicinity, but we can't get down to their horizon. If we wanted to get this type of image for other black holes, it would require an even higher resolution. We've exhausted the diameter of Earth, so we would have to go to a longer baseline, which would be space. If we put radio dishes in space, that would open up numerous other black holes for this type of study.

If we did have that technology, which black hole would you pick to look at?
In a paper in 2012, my colleagues and I identified a bunch of black holes that would all of a sudden become picturable if we could do this from space. I don't have a favourite. What is exciting is there are more than 10 that become suddenly doable. If we could make the technology work and invest in a programme to build it, we could image a whole bunch of other black holes in our vicinity, which would be super fun. ▮

Abigail Beall is a features editor at *New Scientist*

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[1] A New Textiles Economy: Redesigning Fashion's Future (The Ellen MacArthur Foundation, 2017).

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Science of gardening

Ringing the changes

Even the smallest of vegetable patches can benefit from some of the principles of crop rotation, says **Clare Wilson**

Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

A pencil and paper

Science of gardening appears every four weeks

Next week

Citizen science

WHEN I finally reached the top of my local area's long waiting list for allotments, one aspect of vegetable growing that seemed daunting to me was crop rotation. This means dividing your ground into a few different patches and changing where you grow your plant varieties year on year. The intention is to reduce the build-up of pests and diseases, while also improving soil fertility.

Any guidance I could find on doing this seemed complicated, plus it required more ground than I initially had, since most of the new plot was badly overgrown. But as I learned, you don't always have to do things by the book, and even small spaces can receive some benefits from crop rotation.

When British farms adopted a four-year crop rotation of wheat, turnips, barley and clover in the 1700s, it boosted productivity so much it led to a population boom. Key to this was introducing clover, which, being a legume, has root bacteria that can turn nitrogen from the air into compounds for the plant to use, and so boosts soil nutrients. If legume roots are left behind after crop rotation, they benefit plants grown there later.

Legumes popular with today's home gardeners include peas and beans. Once I have harvested the pods, I cut down the stems, leaving everything in place to break down and act as a natural fertiliser for next year's crop. If you don't want to grow peas or beans, and have a spare bed, you can get the same benefit by growing clover over the summer, to act as "green manure".

HALFPOINT IMAGES/GETTY IMAGES

There are various three, four and five-year plans available to use from bodies such as the UK's Royal Horticultural Society (RHS). Be guided by what you most like to eat. A simple three-step crop rotation could consist of only legumes; a nutrient-hungry crop, such as tomatoes, sweetcorn or purple sprouting broccoli; and some root vegetables.

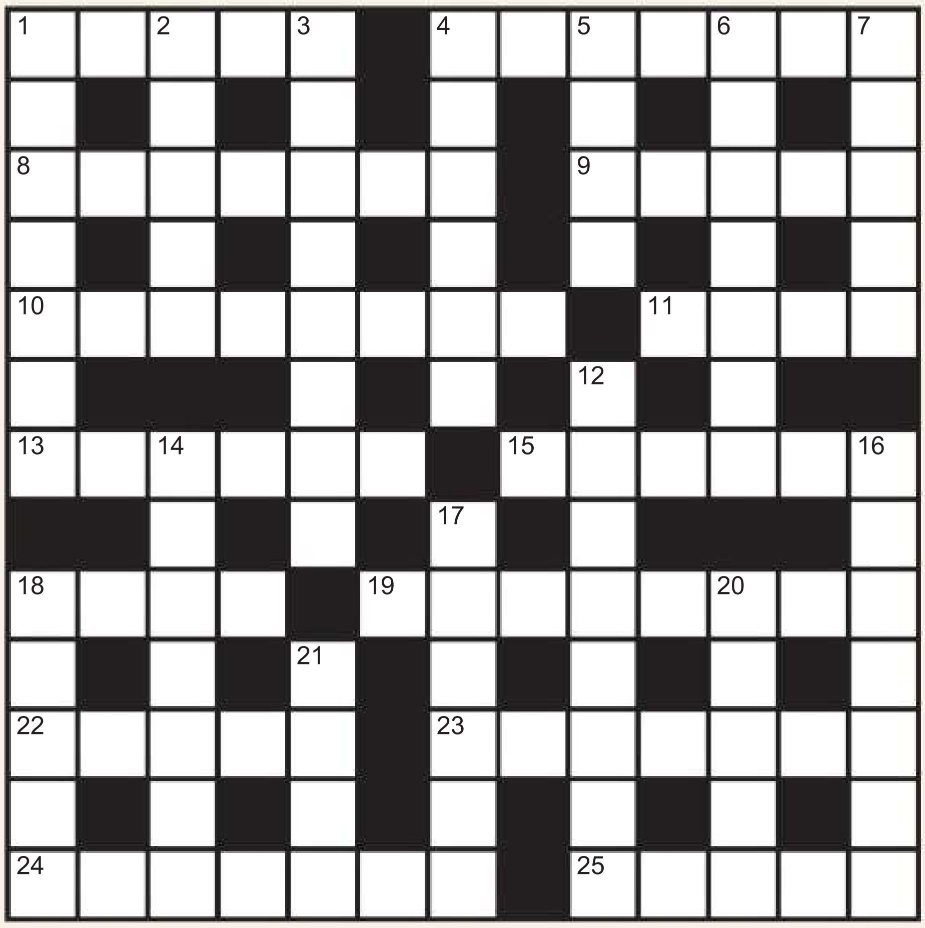
Root vegetables, including carrots and parsnips, can reach down to deeper soil levels than crops from the nutrient-hungry group, says Céleste Mueth, who designed an exhibit about crop rotation for last month's RHS Chelsea Flower Show in London. Root vegetables also break up the soil, which is appreciated by the next crop. Other plants can be grown alongside these staples, depending on the available space.

For people who aren't especially organised – like myself – the key thing is to avoid growing the same plant on the same patch two years running, says Mueth. "There are going to be pests and diseases that can live in the soil through winter," she says. "They will be there, ready to attack your crop."

Twelve years after taking on my allotment, I still haven't made a proper crop rotation schedule. But each summer, I sketch a rough outline showing where my plants have ended up, and this helps me to switch things around in the following spring – otherwise I would struggle to remember. ▮

These articles are posted each week at newscientist.com/maker

Cryptic crossword #86 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Board physicist being audited (5)
4 Gaga played outside a quadrennial event (4,3)
8 Corrode each metal tool, losing half (3,4)
9 Collection of brain nerves present in extraterrestrials (5)
10 Yours truly returning in pursuit of copper scrapers (8)
11 Family acquires large furnace (4)
13 Extract the essence of 1920s art style at court (6)
15 Second-born vacated Zeebrugge (allergic reaction) (6)
18 Herb beginning to drive poorly (4)
19 Female partier trashed unsafe building (4,4)
22 Turn couple of twins away from cyberspace (5)
23 Entails denatured protein (7)
24 Pulsar or piriformis can be spelt either way (7)
25 Hulking ruminants foam at the mouth? (5)

DOWN

1 Run through harbour structure and nearly give up (7)
2 Perfumer's ingredient next to sealant (5)
3 Kelvin and I developed nicest branch of chemistry (8)
4 Attractive person revamped role, gaining approval (6)
5 Too calm, essentially? Correct (4)
6 Mo cried out, "Rodents!" (7)
7 Rambling tale about eastern pine (5)
12 Andre, rent room south of uranium pit (8)
14 Musician, one engaged in cytology? (7)
16 Former partner criticises energy field (7)
17 Straight lithium within reach (6)
18 Scare off forest creature eating last piece of fruit (5)
20 Relationship wretch goes over bit by bit (5)
21 Graph pressure against area (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #157

1 Name the first woman to go to space twice.

2 In what year did Roald Amundsen's team first reach the geographic South Pole?

3 Italian chemist Ascanio Sobrero is best known for inventing which chemical?

4 What cells make up the majority of the epidermis layer of human skin?

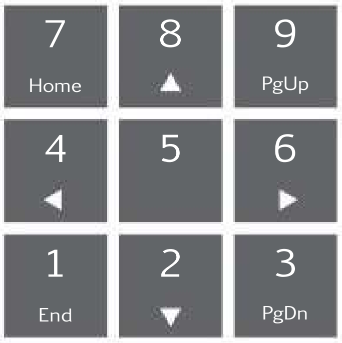
5 Which ancient hominin's scientific name translates to "working man"?

Answers on page 55

Puzzle

set by Peter Rowlett

#173 Knight moves



My son is obsessed with chess, and has been acting out the game's moves everywhere we go, running like a bishop and jumping like a knight on tiled floors. He was tickled to see that on the number pad of my keyboard he could type 27 using a knight's move, because the move from 2 to 7 is an L-shape, like a knight moves on a chessboard.

Alas, he can't make 27 using a bishop move. Bishops move diagonally any number of spaces, so a bishop, using multiple moves, could make a number like 484 or 9157. In a similar fashion, a knight could make numbers such as 167 or 8349.

Yesterday, he made a happy discovery: a three-digit knight number that is exactly 27 more than a three-digit bishop number. (Actually, I found I could put another digit, call it "X", at the front of my son's numbers, and still have a knight number that is exactly 27 more than a bishop number.) What numbers did my son find?

Solution next week

Dew time

My washing is hanging to dry outside and I need to bring it in before dew forms on it. How do I know at what time or temperature that will be?

Peter Meehan
London, UK
Hang a fir cone on the washing line, in the shade. It will close up in humid air.

Mike Follows
Sutton Coldfield, West Midlands, UK
Water vapour will condense onto a surface when the air temperature falls below the dew point – the temperature at which the air is saturated and can hold no more water vapour. As the temperature falls, more water vapour will condense.

Predicting when to bring the washing indoors is tricky as there are many variables, including the material of the clothes, whether it is sunny, the temperature and humidity of the surrounding air and how much the clothes are flapping around in any breeze.

> **"Predicting when to bring the washing indoors is tricky as there are so many factors that influence dew formation"**

As well as dripping from the washing, water will evaporate from wet clothes, taking with it the latent heat of vaporisation, at least until the surrounding air becomes saturated. This evaporation will raise the humidity and dew point of the air in direct contact with the clothes. At the same time, the temperature of the clothes is lowered, which can be exacerbated by heat transfer via convection and radiation. Additionally, the temperature of the air in contact with the clothes will fall as heat is transferred down the temperature gradient from the warmer air to the cooler clothes.

If the air temperature falls below the dew point, unless there is a heat source (generally the sun) or a breeze to replace the humid air next to the clothes with drier air, an equilibrium between evaporation and condensation is reached, which prevents any further drying.

Chris Szymonski
Waupaca, Wisconsin, US
The temperature of the wet laundry being dried outside stays close to the dew point temperature of the air in the area.

As the air temperature goes up throughout the day, the relative humidity of the air (expressed as per cent saturation of the air with water vapour) decreases. This also means that the ability of the air to hold moisture increases. In other words, closer to noon, the air is capable of holding more moisture.

In the early evening, when the air temperature drops, the opposite effect takes place, thus the relative humidity gradient between clothes being dried and the surrounding air drops towards zero, and the drying effect stops.

A handheld psychrometer to measure the relative humidity of the air would do the trick. Just remove the laundry when this comes close to 100 per cent.

Stephen Johnson
Eugene, Oregon, US
Typically, the combination of temperature and humidity required for dew to form is most likely in the early morning when few people would attempt to dry laundry outside, if for no other reason than there is little to no sun.

Under rare or extreme conditions, it is possible for dew to form in the middle of the day – for instance, just before a severe storm driven by a cold front. As an extreme example, the highest dew point ever recorded is 35°C in Saudi Arabia during a day with an outside temperature of 42°C. The lowest dew point was -29°C on a 34°C day in Coober Pedy, Australia.

If you want to know the dew point, it can be calculated from temperature and relative humidity, or measured by many inexpensive hand instruments.

@steve_tees
via Twitter
It will always be just before you decide it is time to bring the washing in.

SIMONSKAFAR/GETTY IMAGES

When a battery is fully charged, like the one in an electric car, does it become heavier?

This week's new questions

Battery boost **Does my electric vehicle weigh more after I have charged it?** ***Doug Bates**, Exeter, UK*

Fossil afterlife **What would be the best way to fossilise my body after I die? And would an inscribed gold plate with my epitaph survive a few million years in rock, in case a future archaeologist finds my fossil?** ***Marthinus Roos**, Elgin, Moray, UK*

Ouch!

Why is pain so painful? After all, it is only nerve impulses sent to our brains like many others.

Neil Frizzo
Newcastle, New South Wales, Australia
Pain is so painful because the consequences of it not being so are worse.

@PhilMorey8
via Twitter
The function of pain is to stop you doing stupid things twice. It has to hurt to make it work.

Pat French
Rockhurst, Shropshire, UK
The impulse sent by a nerve from the site of a trauma is indeed similar to the impulse from a sensor cell in the retina of the eye or the cochlea of the ear. It is how the brain interprets this input that produces an experience, be it colour, sound or pain.

Herman D'Hondt
Sydney, New South Wales, Australia
The real issue here is that we never

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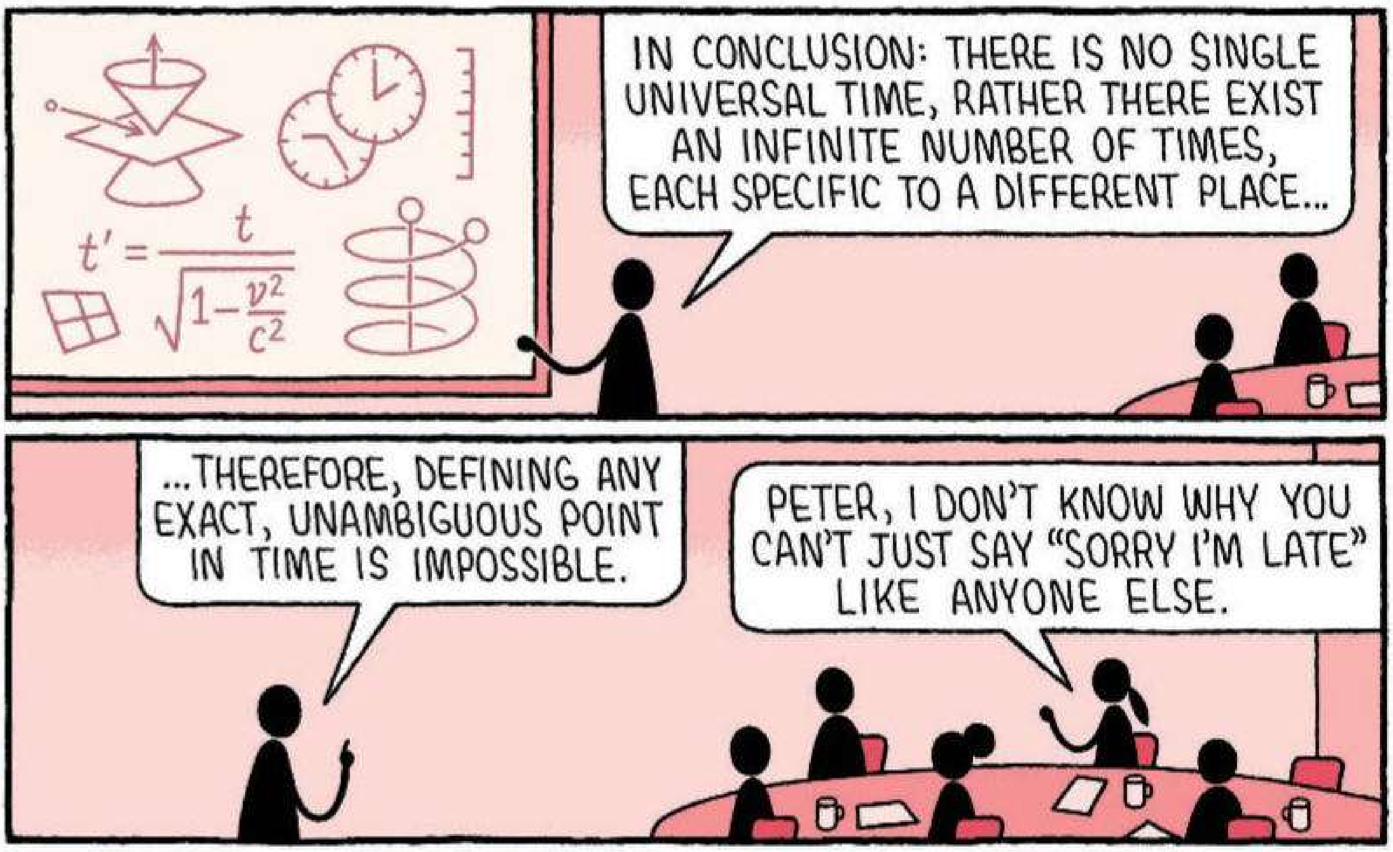

$t' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}}$
IN CONCLUSION: THERE IS NO SINGLE UNIVERSAL TIME, RATHER THERE EXIST AN INFINITE NUMBER OF TIMES, EACH SPECIFIC TO A DIFFERENT PLACE...
...THEREFORE, DEFINING ANY EXACT, UNAMBIGUOUS POINT IN TIME IS IMPOSSIBLE.
PETER, I DON'T KNOW WHY YOU CAN'T JUST SAY "SORRY I'M LATE" LIKE ANYONE ELSE.

perceive reality: what we perceive is only the brain's interpretation of nerve impulses. Nerves were "designed" by evolution to tell animals what was happening inside and around the body. This happened long before there were any brains. There were just nerve signals. Some indicated a touch from another body that was to be avoided; others showed where light was, and that might need to be either sought or avoided. When animals evolved brains, a far greater range of responses became possible.

When a nerve signal arrives in the brain, it is processed by multiple layers of neurons. That processing is what interprets reality. This is easy to see when we look at an optical illusion like the Necker cube, where the processing is unable to decide what we are looking at, and keeps switching between two possible interpretations. It also means that nobody can tell you whether "red" looks the same to them as it does to you. We just know to associate a particular set of nerve signals with the conscious experience that we call "red".

> **"We never perceive reality, only the brain's interpretation of nerve impulses. This is easy to see when we look at an optical illusion"**

In the case of pain, evolution altered our brain to remind us that those signals should be avoided. It would be good, though, if we could switch them off once the pain has been recognised. Why keep reminding me that a burn can hurt, long after it happened?

Tony Durham
Brighton, UK
Pain, perhaps more than pleasure, drives reinforcement learning. It is the past experience of pain that keeps you out of trouble. The pain you feel when you stub your toe represents not only the immediate injury, but also the small but serious risk that you will die as a result. Evolution has decided that injuries have to hurt a lot, in order to give you the best chance of surviving, reproducing and bringing up children.

Cutting it

How would prehistoric people have cut their toenails? (continued)

Rosemary van Essen
Palmerston North, New Zealand
I am not convinced that toenails would be abraded by contact with the ground, as outlined in previous replies. As someone who goes half the year barefoot, walking on a variety of surfaces, I am still required to trim my nails.

Unlike dogs, for example, human toenails remain high off the ground, and I have noticed that people used to walking on rough surfaces also lift their feet higher than town dwellers do. I am not doing as much rough walking as a prehistoric person, of course. But in my experience, to keep toenails short without intervention, you would have to be doing an extreme amount of rock climbing – or stub your toes a lot! ▮

Answers

Quick quiz #157
Answers

1 Svetlana Savitskaya. She was also the first woman to perform a spacewalk
2 1911
3 Nitroglycerine
4 Keratinocytes
5 *Homo ergaster*

Quick crossword #110 *Answers*

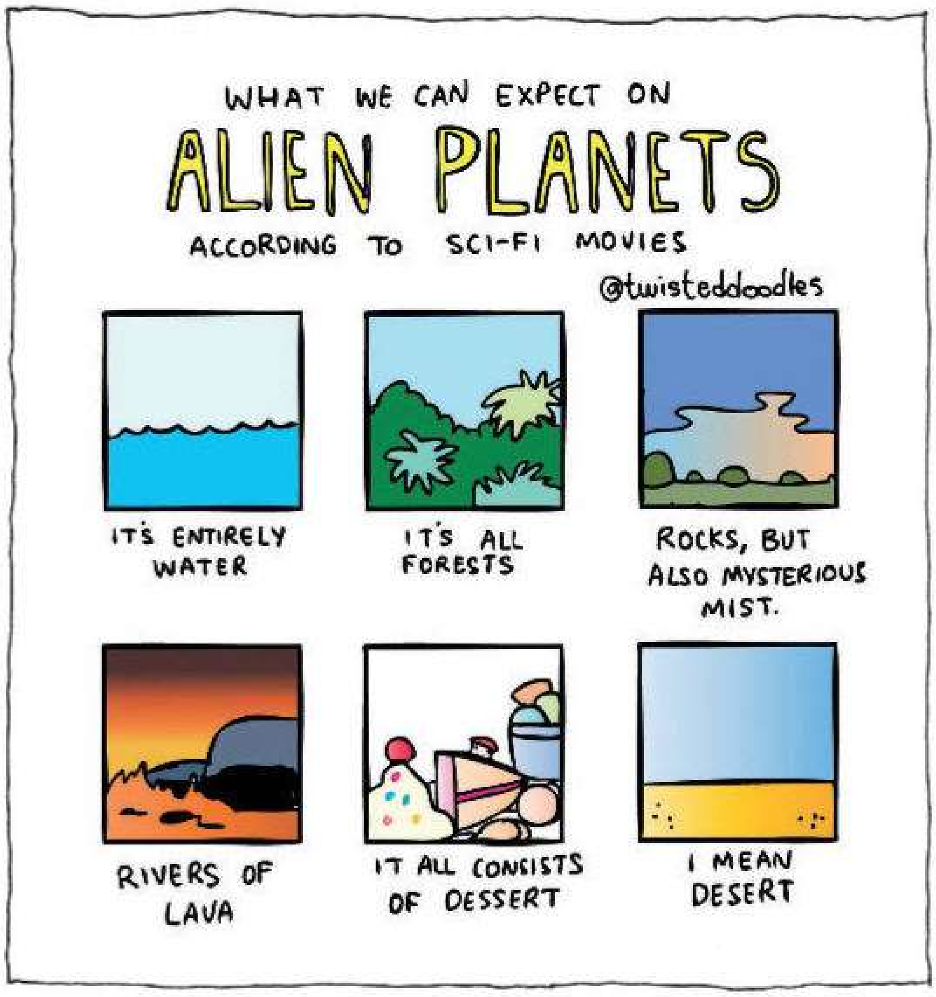
ACROSS 1 Avogadro's Law, **10** Korolev, **11** Earache, **12** Voice, **13** Eggshell, **15** Ninety-nine, **16** Smew, **18** Over, **20** Naturalist, **22** Ecobrick, **24** Fungi, **26** Tripoli, **27** Hormone, **28** Neo-Darwinism

DOWN 2 Version, **3** Gillette, **4** Davy, **5** Oleaginous, **6** Loris, **7** Wych elm, **8** Okavango delta, **9** Yellow stainer, **14** Antarctica, **17** Warfarin, **19** Erosion, **21** Igneous, **23** Rhodo, **25** Thaw

#172 Four got it
Solution

The house code is 8712, and the car code is 2178. We need a 4-digit number that, when multiplied by 4, equals the reverse of the original number. It would need to be less than 2500 or it would result in a 5-digit number. The number can't start with 1, since a whole number multiplied by four can't end in 1. If it starts with 0, it has to be 0000 (a number that wouldn't need any memory prompt!) or 0xx5, but that couldn't be multiplied by four to get a number in the 5000s. So, it must start with 2 and end with 8. From that it emerges that the car code must be 2178, with the house code being the reverse.

Twisteddoodles *for New Scientist*



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Consideration of items sent in the post will be delayed

Year of the ET

Feedback is crossing our fingers for Zhang Tongjie, China's foremost proponent of SETI, the astronomy field's search for extraterrestrial intelligence. This mild-mannered academic has spent the past eight years funding his own search for intelligent alien life, labouring from his home office, in between lectures and marking student work.

He got his big break a couple of years ago when he was given 17.5 hours to gather data using Sky Eye, a 500-metre aperture radio telescope in China's Guizhou province. On 15 June, a report on the website of the official newspaper of China's Ministry of Science and Technology revealed that Zhang and his team of two had found "several cases of possible technological traces and extraterrestrial civilizations from outside the Earth" – only for the post to vanish a few hours later.

Did an overenthusiastic press officer get a ticking off? Or are our alien neighbours manipulating time and reality? Feedback has another explanation. In an interview with Chinese news site Sixth Tone, Zhang's colleague Zhao Haichen says he was inspired to join the project after reading Liu Cixin's novel *The Three-Body Problem*. Which is, should you need reminding, the story of a SETI researcher who brings down an alien invasion upon the Earth.

Time to heal

In China again: President Xi Jinping's pledge to achieve national net-zero carbon emissions by 2060 has been raising eyebrows for some time. How will China meet such ambitious targets? Enter another Chinese sci-fi writer, Chen Qiufan, author of 2013's fantastic noirish eco-thriller *Waste Tide*.

Chen's new work boasts the rather more pedestrian title *Net Zero China*. He told Bloomberg News: "The protagonist lives today, but can travel through time. He travels to 2060 and witnesses how society works with the help of all kinds of technological breakthroughs and a smooth system that helps the country reach net zero. At the end, he travels back with the new ideas he learned in 2060 and shares them with people who help reach the climate goal."

Not only is this cheating, it also makes no mention of what we imagine to be time travel's catastrophically huge carbon footprint. Mind you, if you used time travel to arrange some crafty off-setting scheme…

Why the long face?

Called simply Man v Horse (because why gild the lily?), on 13 June this most quixotic of races once more pitted species against species across a 36-kilometre course in deepest Powys, UK. This year, *Homo sapiens* triumphed. "It's great to win the event and beat the horse," the winner declared, not at all concerned at undermining a 5000-year effort to get *Equus ferus caballus* to bear us.

"I've never rode a horse in my life," he added. "I once rode a donkey at Blackpool though." Regular reader Ceri Brown asks that we immortalise this runner's name: it is Ricky Lightfoot.

Cover your ears

Far too late for any Legionnaires who happen to be reading this, but these days, the World Health Organization speedily renames diseases so that ill-chosen names don't spread stigma.

It takes a dim view of animal names in particular, and its director-general Tedros Adhanom Ghebreyesus is already planning action on the monkeypox virus, not least after an open letter from more than 30 scientists on the message board of virological.org.

When we last looked, the comments on that post contained only a single suggestion for a new name: Human Orthopox Syndrome, or HOPS. Feedback wonders if this suggestion will, like Beatrix Potter's Peter, creep under the wire?

The kraken wakes

Public outreach is a chore for some scientists, but not for Connecticut marine biologist Sarah McAnulty, whose natty embroidery cephalopods can be found on her Etsy page. Now she is courting a prang or two from tailgaters by scrawling, across the back of her car, an invitation to text "SQUID" to her hotline for the latest squid facts. So far, she says, a staggering 39,260 cephalophiles have reached out.

Do the squirm

"Limbless crawling is ubiquitous in biology," say Sreejith Santhosh and Mattia Serra at the University of California, San Diego. It is rampant here, too, especially when it comes to Feedback's pay review. The physicists' recent joint paper, "Optimal Locomotion for Limbless Crawlers", reveals convergent evolution in all its peristaltic magnificence. The physics of undulating locomotion offers, say the authors, "insights and tools for optimal bioinspired crawling robots". Would that they had not gone on to mention "applications in search and rescue, endoscopy and burrowing". At the very least, those ideas need putting in a happier order.

Thank me very much

Finally, may we congratulate Charles Corfield who, through a glitch, has just received a *New Scientist* gift subscription from himself. Feedback isn't sure if cloning has suddenly made strides or we are just ahead of the times.

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